STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

CLEAR CREEK FISHERY STUDY

MARCH 1986

Gordon K. Van Vleck
Secretary for Resources
The Resources Agency

George Deukmejian
Governor
State of California

David N. Kennedy
Director
Department of Water Resources

C—064798

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ON THE COVER: Saeltzer Dam (top left), located at stream mile 6.0, presently blocks upstream migration of salmon and steelhead. Pool (top right) upstream of Saeltzer Dam provides outdoor recreation close to the Redding area. A DWR engineer (lower right) makes flow measurements for the instream flow study.

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FOREWORD

The Department of Water Resources is committed to protect, develop, and manage California's water for all beneficial uses, including recreation and fish and wildlife uses. The Department's internal policy suggests that ". . . instream water uses for recreation, fish, wildlife, and related purposes shall be balanced with other uses."

In support of this policy, the Department has incorporated protection and restoration of fishery habitat as part of its future water development program in the Sacramento River Basin. The Department's Northern District surveyed several tributary streams in 1982 to determine the potential for improving fisheries, recreation, and aesthetic quality. Clear Creek, the first major tributary of the Sacramento River below Shasta Dam, was selected for concentrated study because it appeared to be the most promising for enhancement of the fishery. Restoration of Clear Creek could provide substantial opportunities for increasing anadromous fish runs in the Sacramento River system as well as increasing opportunities for fishing, swimming, and other recreation.

This report describes the Department's study and presents suggestions for rehabilitation of the fishery and enhancement of recreational opportunities in the Clear Creek area.

Wayne S. Gentry

Wayne S. Gentry, Chief
Northern District

STATE OF CALIFORNIA
George Deukmejian, Governor

THE RESOURCES AGENCY
Gordon K. Van Vleck, Secretary for Resources

DEPARTMENT OF WATER RESOURCES
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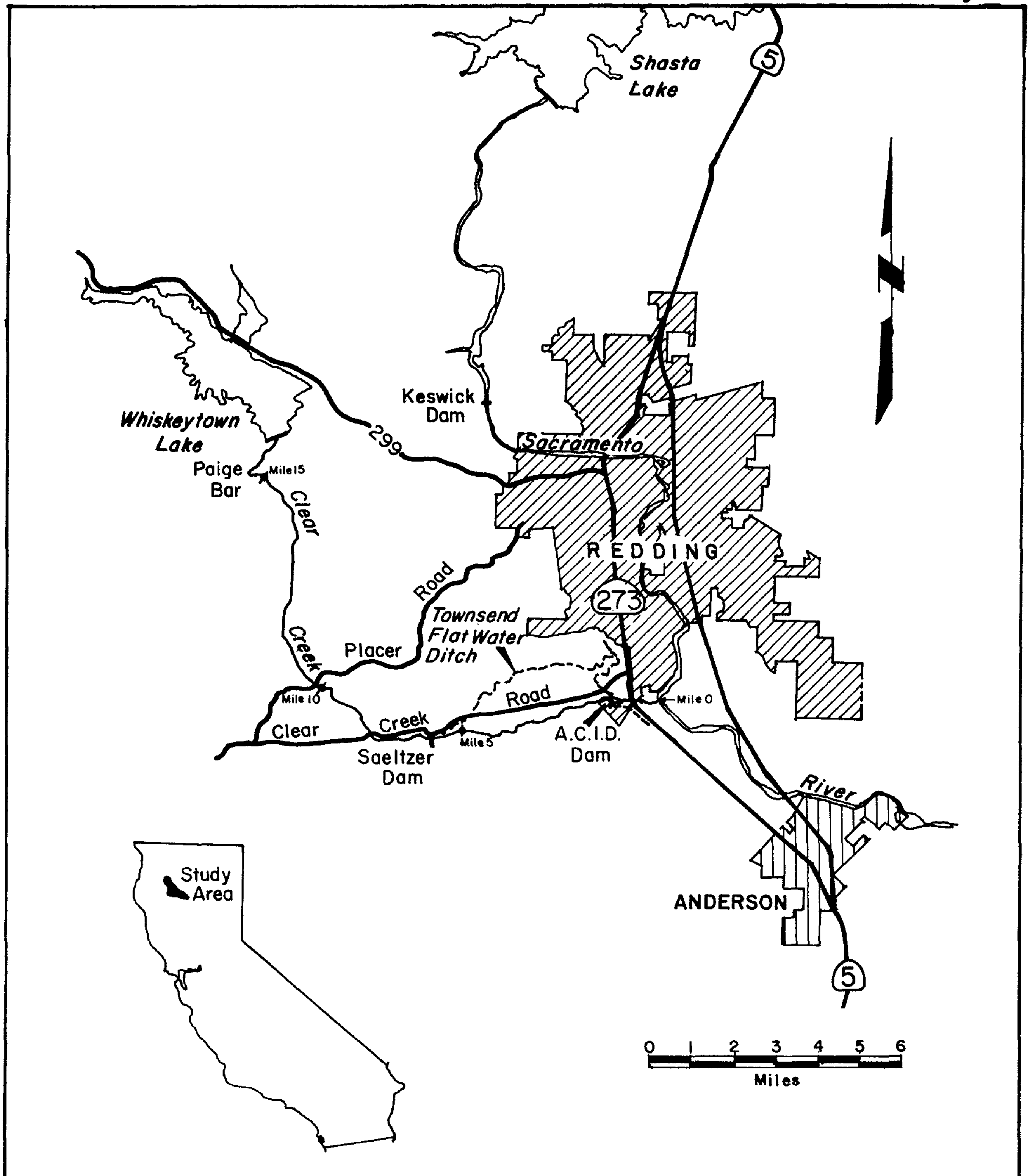


Location Map
Clear Creek Study Area

C-064806

CHAPTER I. INTRODUCTION

Summary

Water management policy of the Department of Water Resources includes a balanced interest in nonconsumptive instream water uses for recreation and fish and wildlife purposes as well as for consumptive uses such as domestic, municipal, industrial, and agricultural. One expression of commitment to this policy is the Clear Creek fishery study, which concentrates on water for instream uses in the upper Sacramento River system near Redding. Beneficiaries of such water use include the commercial fishing industry, as well as those who enjoy fishing, swimming, rafting, and tubing or simply walking along a healthy stream system.

Clear Creek has experienced fishery habitat degradation problems similar to the nearby Trinity River, including diversion of most of its water supply, heavy sedimentation from decomposed granite sand, riparian vegetation encroachment, reduction of available spawning gravels, and past mining damage. However, the creek still supports a sizable run of salmon and a few steelhead, which could be substantially increased by modified flow releases and by implementing habitat restoration measures.

Clear Creek is relatively unusual in that the majority of its fishery-improvement potential lies in the lower 8 miles, where streamflow is almost totally controlled by Whiskeytown Dam located at mile 16.5. Consequently, much of the fishery habitat improvement could be accomplished immediately, simply by releasing increased water below the dam. The remainder of this chapter presents study findings and recommends specific actions to greatly increase the anadromous fishery use of Clear Creek.

Findings

1. Clear Creek is the first major tributary to the Sacramento River below Shasta Dam. It is an important stream for salmon production, local recreation use and as a greenbelt divide between the rapidly growing communities of Redding and Anderson. This area is rapidly urbanizing and is losing much of its natural character.

2. Chinook salmon spawn heavily in the lower 6 miles of Clear Creek during years when early fall rain provides suitable attraction flows. Spawning use was measured at 4,000 salmon in 1982 and 2,000 in 1983. Average spawning since 1951 is estimated at approximately 1,950 salmon per year.

3. Salmon can be attracted to Clear Creek by increased flow releases from Whiskeytown Dam, as evidenced by the large run in 1963-64 (10,000 fish). That year, water releases ranging from 500 to 1,500 cfs were made from September through February.

4. Suitable habitat, particularly clean spawning gravels, is a limiting factor affecting anadromous fishery production in Clear Creek and the upper Sacramento River. Clear Creek could provide much additional spawning and rearing habitat for both salmon and steelhead if habitat restoration work is performed.

5. The large amount of decomposed granite sand produced by Clear Creek tributaries below Whiskeytown Dam, combined with the lack of high-volume flushing flows and the blockage of gravel originating upstream of the dam, adversely affects the availability and suitability of spawning gravels. Gravel gradation analysis taken during this study consistently showed excessive sand, which adversely affects egg survival.

6. Saeltzer Dam at mile 6 presently blocks all anadromous fish from the 10 miles of stream between Saeltzer and Whiskeytown Dams. A tunnel fish ladder constructed in 1958 proved to be unsuccessful in providing fish passage around the dam. There are 2 miles of good salmon and steelhead spawning habitat immediately above Saeltzer Dam and 8 miles of fair-to-poor steelhead rearing habitat above that. These areas could be substantially improved once suitable fish passage is provided.

7. Historic gravel mining activity in the lower 4 miles of Clear Creek has resulted in the loss of tremendous amounts of spawning gravels. The only significant remaining gravel sources within the flood plain are located between miles 3 and 5. Removal of the majority of these remaining gravels for commercial use has been proposed by the property owner.

8. The quantity and quality of fishery habitat in Clear Creek have declined significantly during the last 20 years, due to low sustained flow releases below Whiskeytown Dam, reduced incidence and intensity of flushing flows, mining of spawning gravel sources, increased amounts of sand-size sediment, and riparian vegetation encroachment.

9. Present flow releases represent about 13 percent of the natural flow of Clear Creek at Whiskeytown Dam. Flows recommended as a result of this study represent about 24 percent of the natural runoff. These flows could greatly increase the quality and quantity of habitat for both salmon and steelhead.

10. Intensive use of Clear Creek's available spawning habitat during years of high attraction flows caused by early storms or Whiskeytown Dam releases indicates that additional constructed or rehabilitated habitat would be used by spawning fish.

Recommendations

The following actions, if taken by Federal, State, and local agencies, would significantly improve the Clear Creek fishery.

1. Additional flow from Whiskeytown Dam could be released in a schedule similar to that shown in Figure 7, page 57. These releases, when added to natural inflow from lower creek tributaries, would total 150 cfs at Saeltzer Dam from April 1 through October 15, and 200 cfs the rest of the year. Additional attraction releases should be made periodically during the fall to coincide with natural storms, suitable water temperatures, and movement of fish in the Sacramento River. Effects of the suggested releases should be monitored and the release schedule "fine-tuned" as its fishery impacts are determined.

2. Spawning riffles should be reconstructed in at least the following three areas: (1) the flood-damaged Renshaw riffle, mile 4.5 to 4.8; (2) the Oaks and Schmidt properties, mile 3.5 to 4.0; and (3) below Highway 273, mile 0.4 to 0.7.

3. Suitable portions of all major riffle areas in the lower 6 miles of Clear Creek should be ripped to loosen compacted gravels and reduce the amount of silt and sand-size sediment present.

4. The fish ladder at Saeltzer Dam should be reconstructed to allow effective fish passage above the dam.

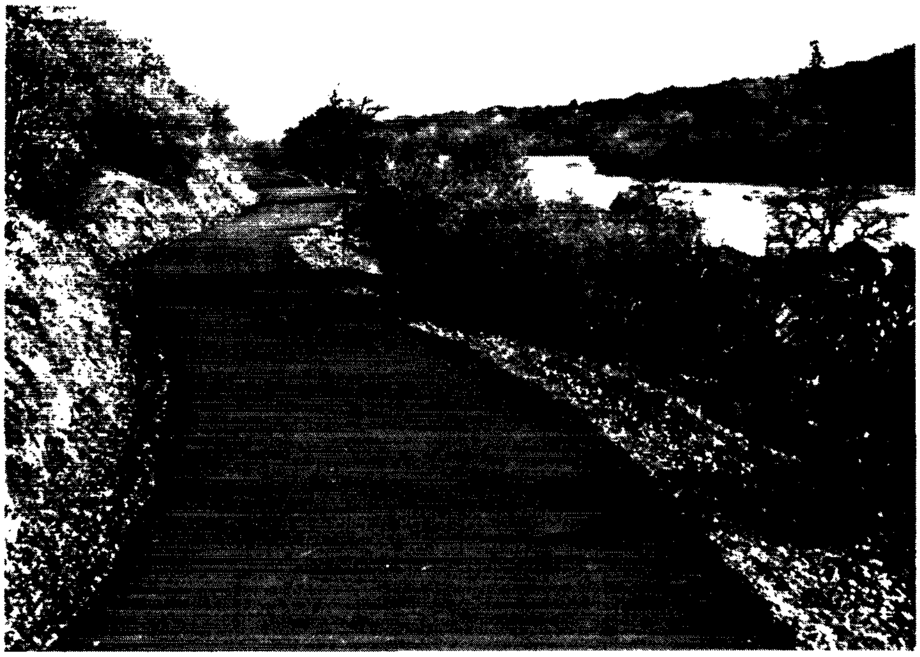
5. The Department of Fish and Game (DFG), working through the State Wildlife Conservation Board and in cooperation with Shasta County and the City of Redding, should either purchase land along portions of the Clear Creek flood plain or obtain long-term easements to allow restoration and protection of fish and their habitat. A walking-jogging-cycling trail system, similar to the one on the Sacramento River below Keswick Dam, could be developed in conjunction with this recommendation.

6. Shasta County should continue to enforce zoning ordinances along Clear Creek to prevent extraction of spawning gravels from within the Clear Creek designated floodway.

7. A program should be initiated to implement the fishery habitat restoration opportunities discussed in Chapter V.

8. Funding should be identified to implement the restoration measures presented in this report.

Spawning and rearing gravels have been greatly depleted in Clear Creek. The few remaining gravel terraces adjacent to Clear Creek (above) should be protected from extraction because they provide the greatest natural replenishment source. If streamside reaches of Clear Creek are purchased for fishery enhancement, a recreational trail system similar to that recently constructed along the Sacramento River near Keswick Dam (below) could be built.



CHAPTER II. BACKGROUND AND STUDY AREA DESCRIPTION

In recent years, Californians have become increasingly aware of how the natural environment affects their welfare. After observing numerous examples of land and streams excessively modified to unnatural states in large urban areas, many people have developed a strong commitment to preserving much of the remaining natural systems. However, turning those commitments into reality is difficult when society's collective livelihood must be derived from the land. Therefore, wise planning and careful stewardship of land and water resources have become a major concern of public agencies, such as the Department of Water Resources (DWR).

DWR has an obligation to protect, develop, and manage California's water for all beneficial uses, including recreation and fish and wildlife purposes. DWR internal policy suggests "that instream water uses for recreation, fish, wildlife, and related purposes shall be balanced with other uses."

A beaver swims upstream in Clear Creek.

In support of this policy, DWR's Northern District surveyed several Northern California streams in 1982 to determine the potential for improving their fishery, recreational, and aesthetic quality through increased instream flows and habitat restoration work. Streams initially evaluated were the Scott River, and Clear, Churn, Mill, and Deer Creeks. Clear Creek was selected from among these streams for concentrated study because it was the most threatened by urban development and because it offered an excellent opportunity for immediate fishery enhancement.

One of the creek's most apparent enhancement possibilities is the capability of Whiskeytown Dam to improve instream flows in the lower 16 miles of creek simply by increasing releases from the Dam. The operator of Whiskeytown Reservoir, the U. S. Bureau of Reclamation, through The Secretary of the Interior, has a commitment stated in the implementing legislation "to adopt appropriate measures to insure the preservation of fish and wildlife, including ...the maintenance of the flow of Clear Creek...."

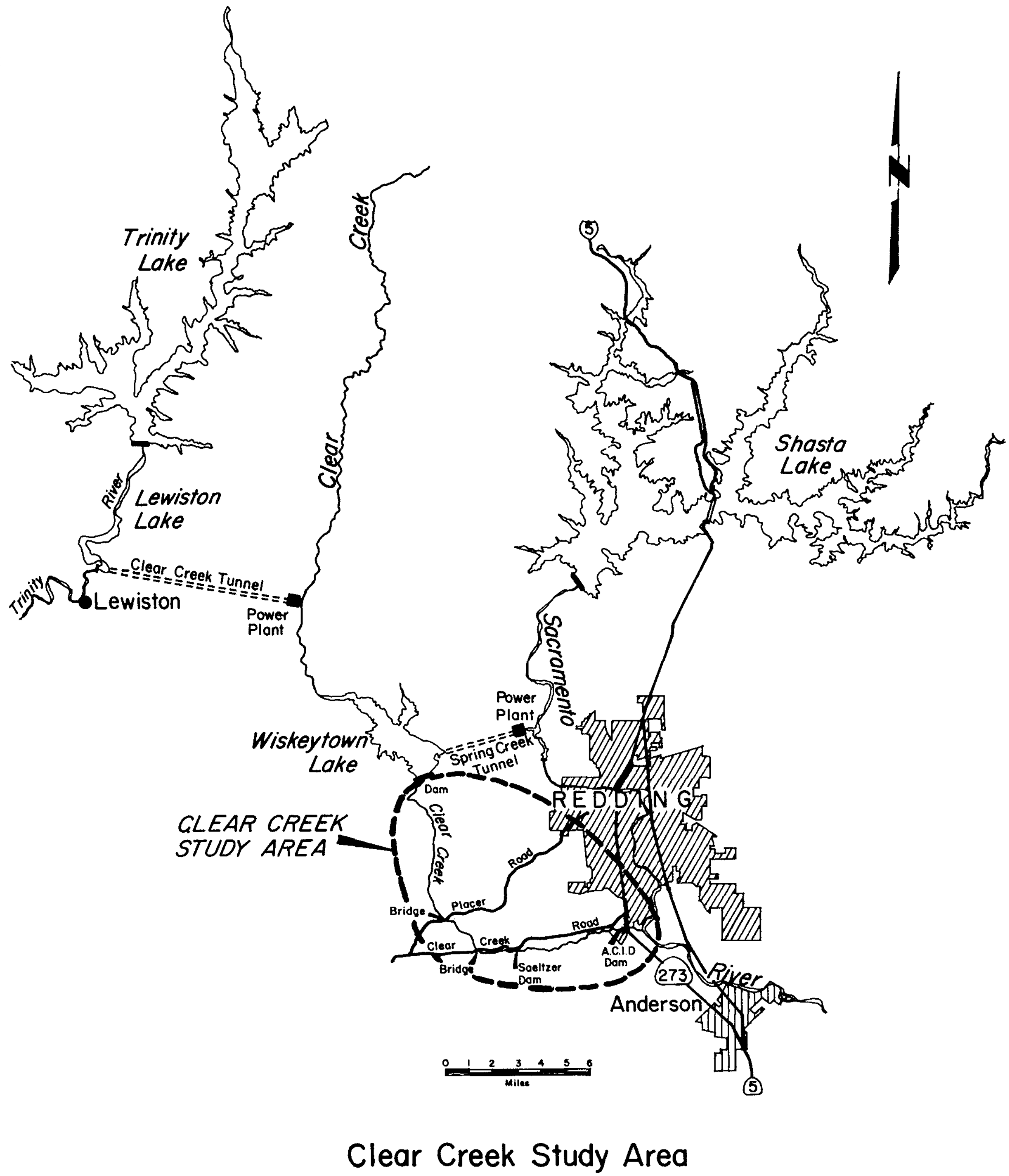
Another reason the Department is interested in fishery habitat improvement on Clear Creek, as well as the rest of the Sacramento River system, is the relationship between future water development planning and anadromous fisheries. The Department has incorporated protection and restoration of fishery habitat as a part of its future water development program on the Sacramento River. Improvement of Clear Creek could be a key feature of the restoration efforts.

Study Area

Clear Creek is a major westside tributary of the Sacramento River and has a drainage area of 238 square miles. It begins in the mountains east of Trinity Lake, approximately 35 miles from its confluence with the Sacramento River, and flows into the Sacramento River near the South Redding city limits. Whiskeytown Dam and Reservoir stores natural creek flows and water diverted from the Trinity River at Lewiston through the Clear Creek Tunnel. All of the Trinity River water and 87 percent of the natural flows of Clear Creak are diverted through the Spring Creek Tunnel to the Sacramento River above Keswick Dam. The remaining 13 percent is released to Clear Creek. The Clear Creek study area (Figure 2) includes the entire 16.5-mile reach below Whiskeytown Dam. However, most of the study effort was concentrated along the 6-mile portion of creek from Saeltzer Dam to the mouth because anadromous fish cannot presently pass above the dam.

The terrain of Clear Creek can be divided into two predominant types at the Clear Creek Road Bridge (mile 7.9). Upstream, the creek is steep with many falls and cascades and is surrounded by high canyon walls. The creek bottom is composed mostly of large rock and decomposed granite sand. By contrast, the 8 miles of creek below the bridge have a flatter gradient with few cascades or falls, and the creekbed material is composed mainly of gravel mixed with sand. Most of the suitable fish-spawning and rearing gravels are located in this reach.

Figure 2



Clear Creek Study Area

Whiskeytown Dam to Sacramento River

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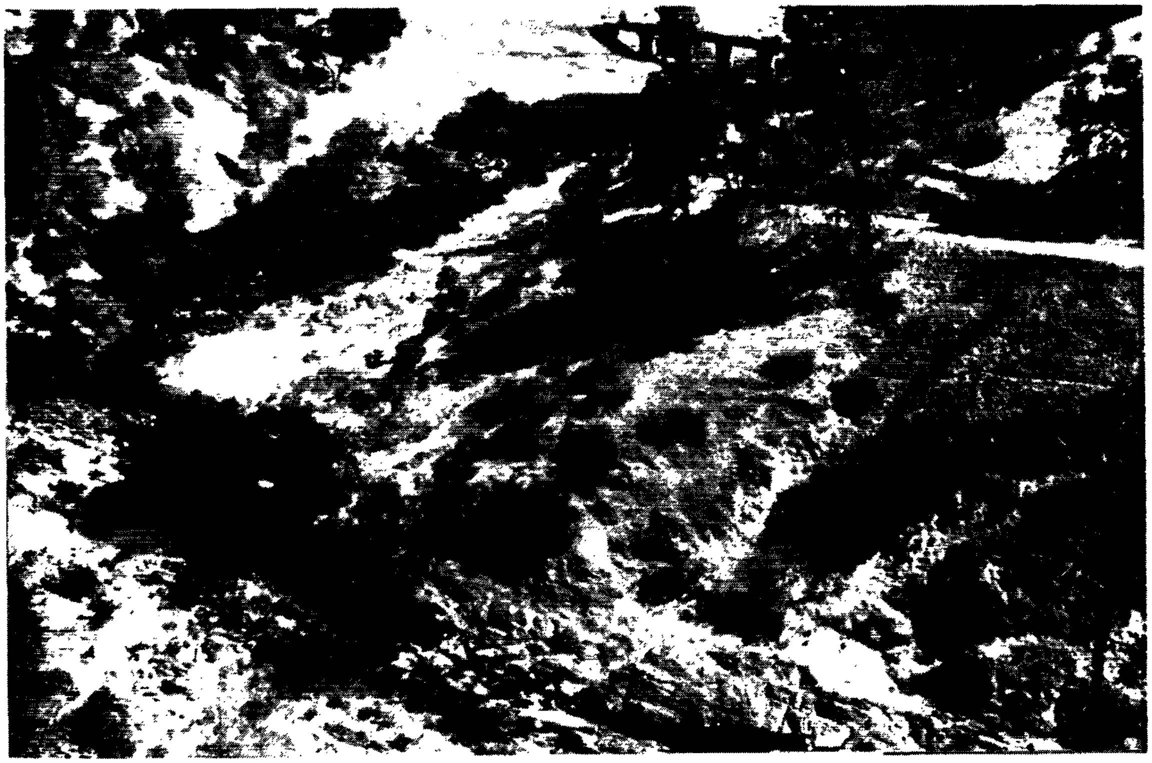


The canyon area of Clear Creek, above, contrasts with the flatter reaches downstream from mile 7.9 below.

The lower 8 miles of stream basin were mined by gold dredges several decades ago. Approximately 600 acres of dredger tailings from this mining activity can still be observed north of Clear Creek Road. These tailings are presently being processed for aggregate products and will be completely used in about 40 years.

Extensive aggregate mining of the Clear Creek channel and surrounding area in the lower 3-1/2 miles occurred during the 1950s through the 1970s. Mining in the Clear Creek channel is not occurring now, but the detrimental effects of past mining on the creek's gravel sources linger on. Aggregate mining has resulted in the general absence of large gravel terraces, the existence of several large gravel-extraction pits, and a relatively flat cross-section to the flood plain.

The 15-foot-high Saeltzer Dam at mile 6 was constructed in the early 1900s to divert water into the Townsend Flat Water Ditch. This ditch is the only large water diversion below Whiskeytown Dam. It takes up to 18 cfs during summer months to irrigate approximately 200 acres of land north of the creek. Much of this water seeps through the unlined ditch back to the creek before it can be used for irrigation. The only other significant consumptive use of water occurs on the Renshaw Ranch (mile 4.7), where up to 1 cfs is pumped periodically throughout the summer for irrigation, and at the B & S Gravel Plant, where water is used occasionally for washing gravel. Some property owners in the lower 2 miles divert small quantities of water for garden irrigation.

Saeltzer Dam provides irrigation water to the Townsend Ditch. A tunnel-type fish ladder was constructed around the dam; its exit is in the shadow on the opposite bank.

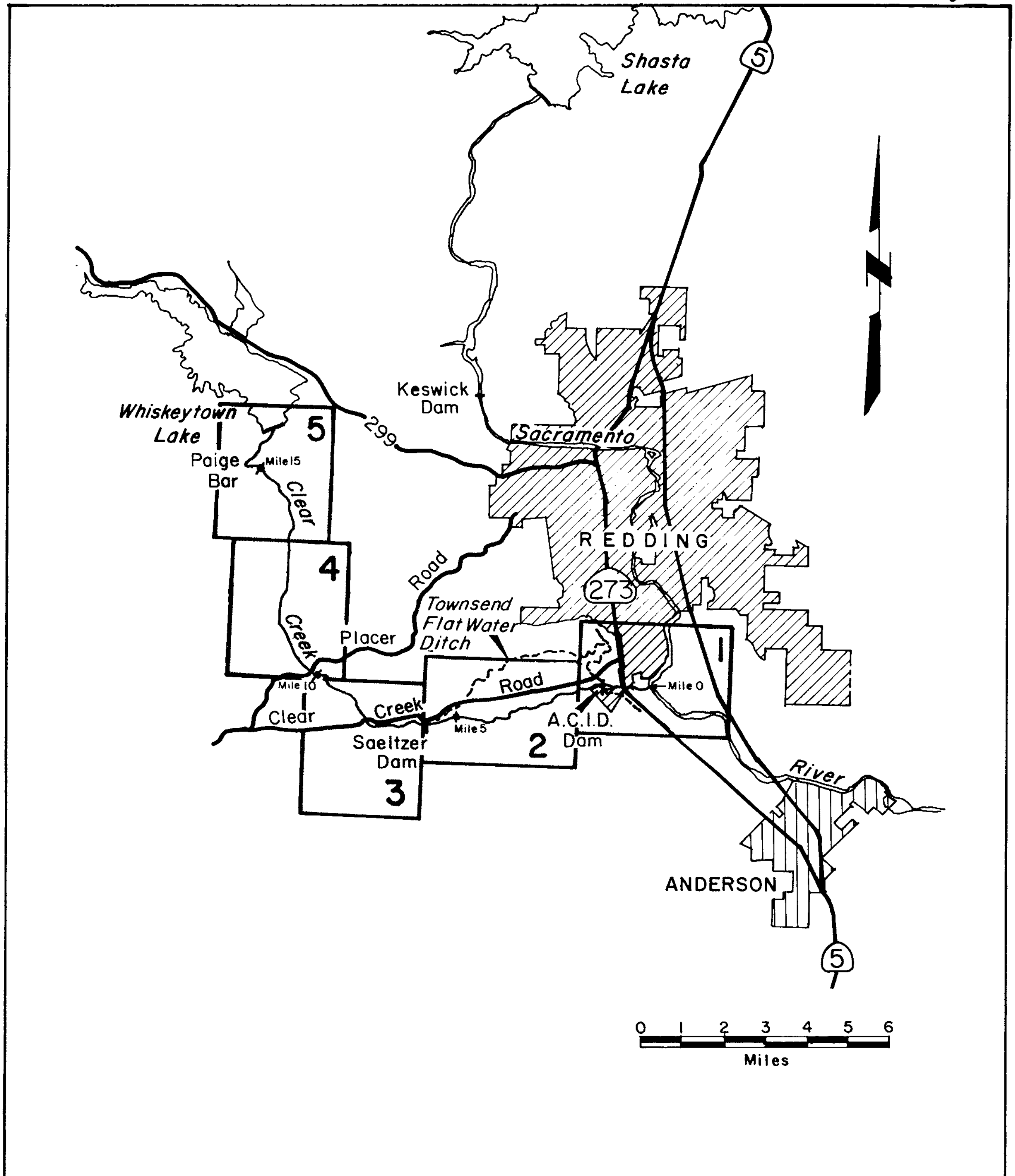
Clear Creek is unique among westside streams tributary to the Sacramento River because it is a constantly flowing stream near a growing metropolitan area that has not yet been extensively developed. Some industrial uses of the land, such as aggregate production, lumber milling, auto dismantling, and truck repair, occur along Clear Creek Road, which parallels the creek approximately one-quarter of a mile to the north. At present only a limited number of homesites or businesses interrupt the natural riparian landscape along the stream.

Clear Creek presently receives substantial public recreation use at several locations even though almost all land along the creek is privately owned. This use includes swimming, fishing, and tubing. Most of the creekside land is posted against public use, and if this restriction is effectively enforced, most future public use will be prevented. The Clear Creek flood plain is presently zoned as green belt by the Shasta County General Plan, which restricts uses to flood control, agriculture, mining, fish and wildlife protection, and recreation. County use permits requiring environmental impact reports are required for any development within the flood plain.

Study Area Atlas

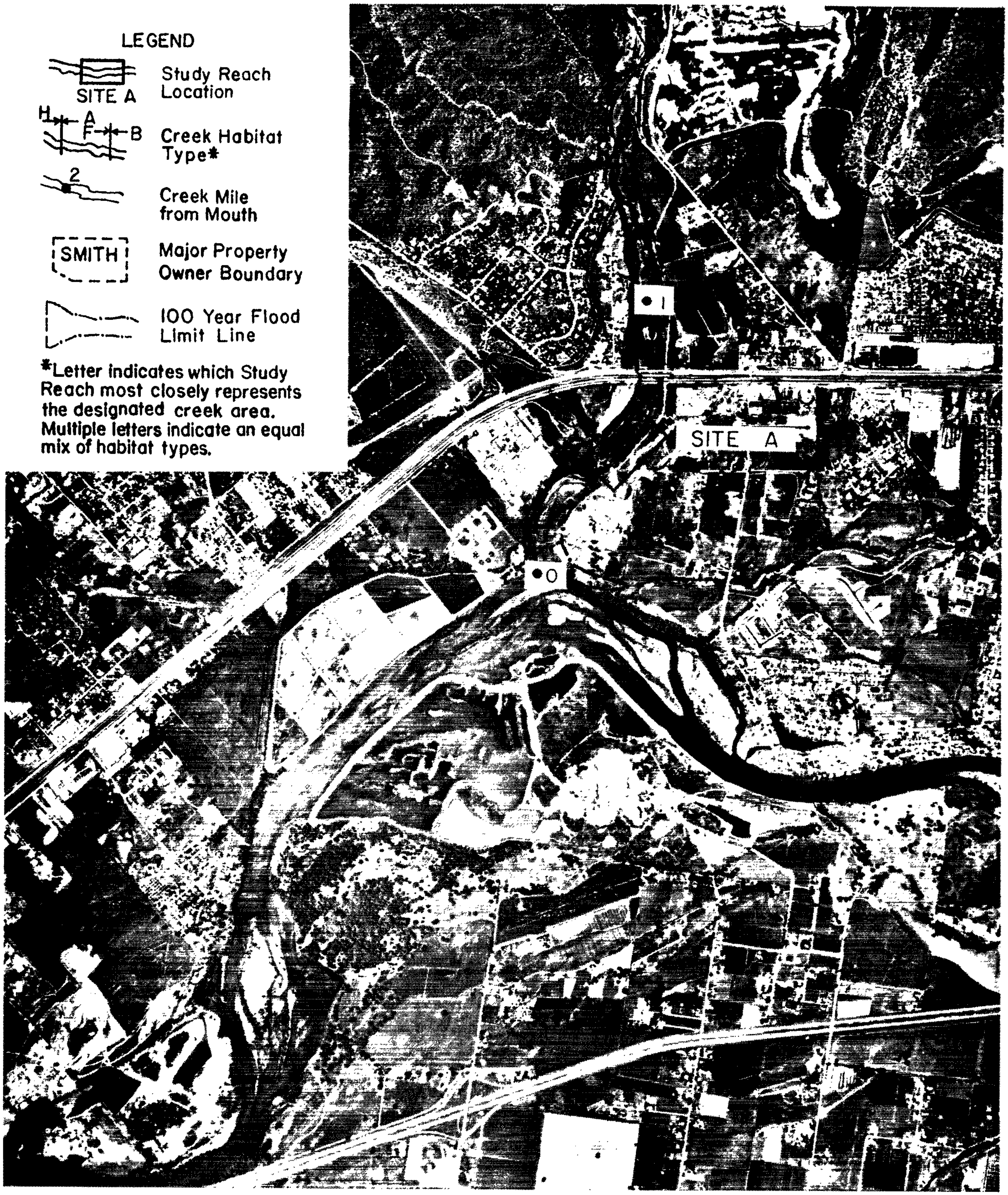
A map-and-photo atlas of the Clear Creek study area from the Sacramento River to Whiskeytown Dam was prepared for this study. The aerial photos were taken during a June 1982 flight. Features added to the base maps and photos are property ownership, creek mileage, the approximate 100-year flood line and details related to the instream flow need study, such as representative study reach locations and their application to the other portions of the creek. The atlas can be used as a detailed reference map for subjects discussed in the remainder of this report.

Figure 3



Clear Creek Atlas Index Map

Plate I


LEGEND
SITE A
Study Reach Location
H A F B
Creek Habitat Type*
2
Creek Mile from Mouth
SMITH
Major Property Owner Boundary
100 Year Flood Limit Line
*Letter indicates which Study Reach most closely represents the designated creek area. Multiple letters indicate an equal mix of habitat types.
1
SITE A
0

Match Plate 2

Plate I

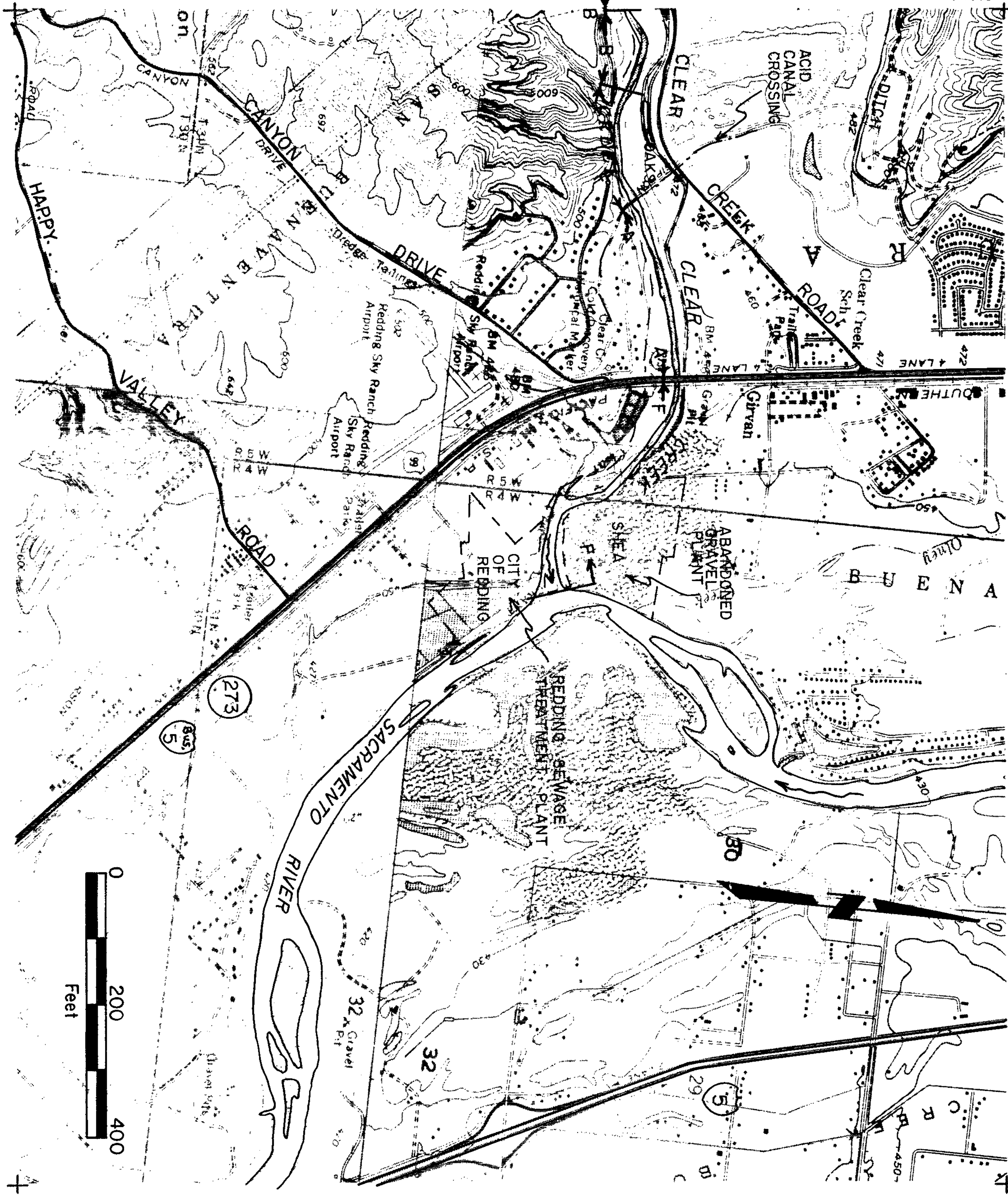


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Plate 2

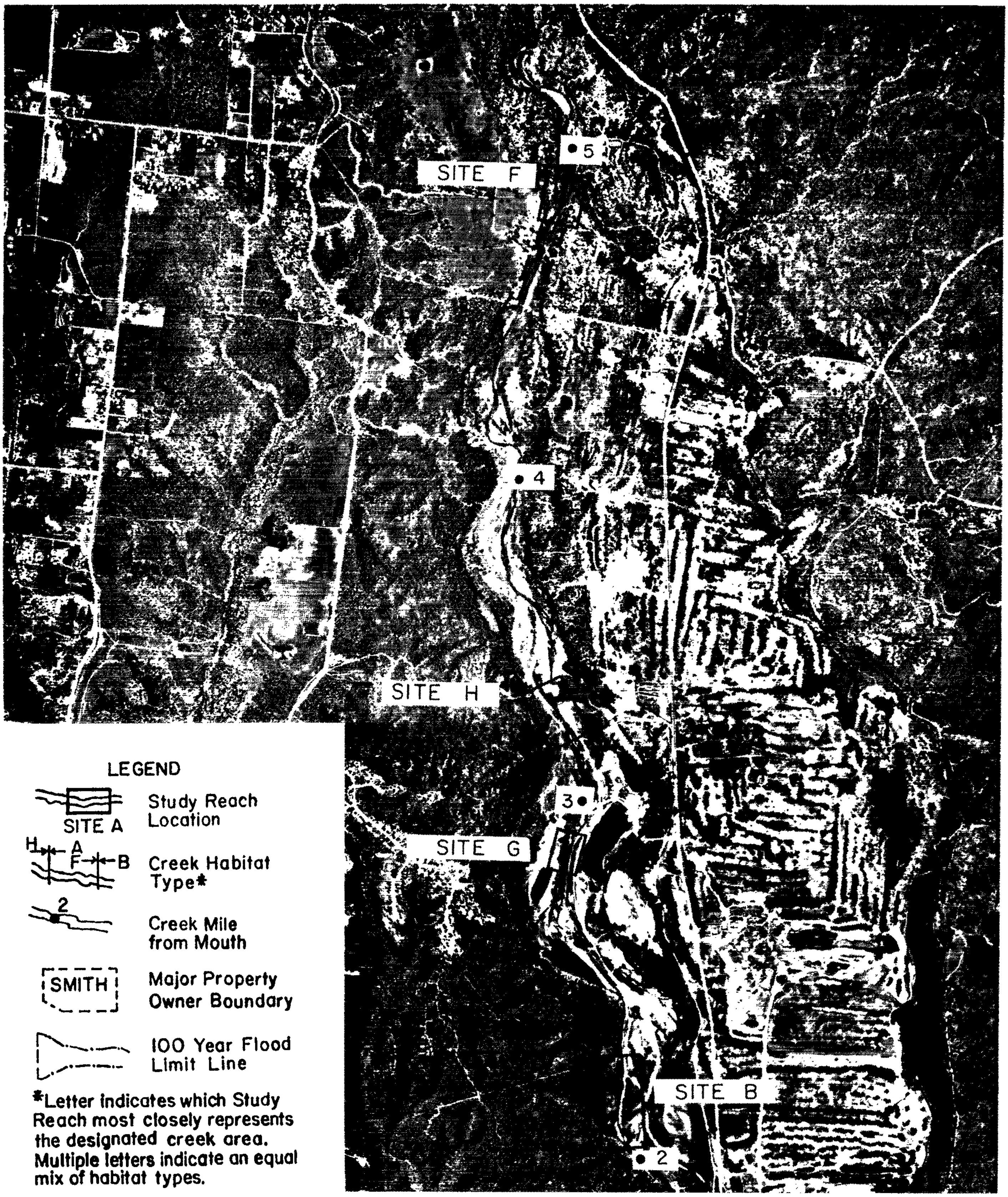
SITE F
5
4
SITE H
3
SITE G
SITE B
2
LEGEND
SITE A
Study Reach Location
H A F B
Creek Habitat Type*
2
Creek Mile from Mouth
SMITH
Major Property Owner Boundary
100 Year Flood Limit Line
*Letter indicates which Study Reach most closely represents the designated creek area. Multiple letters indicate an equal mix of habitat types.

Plate 2

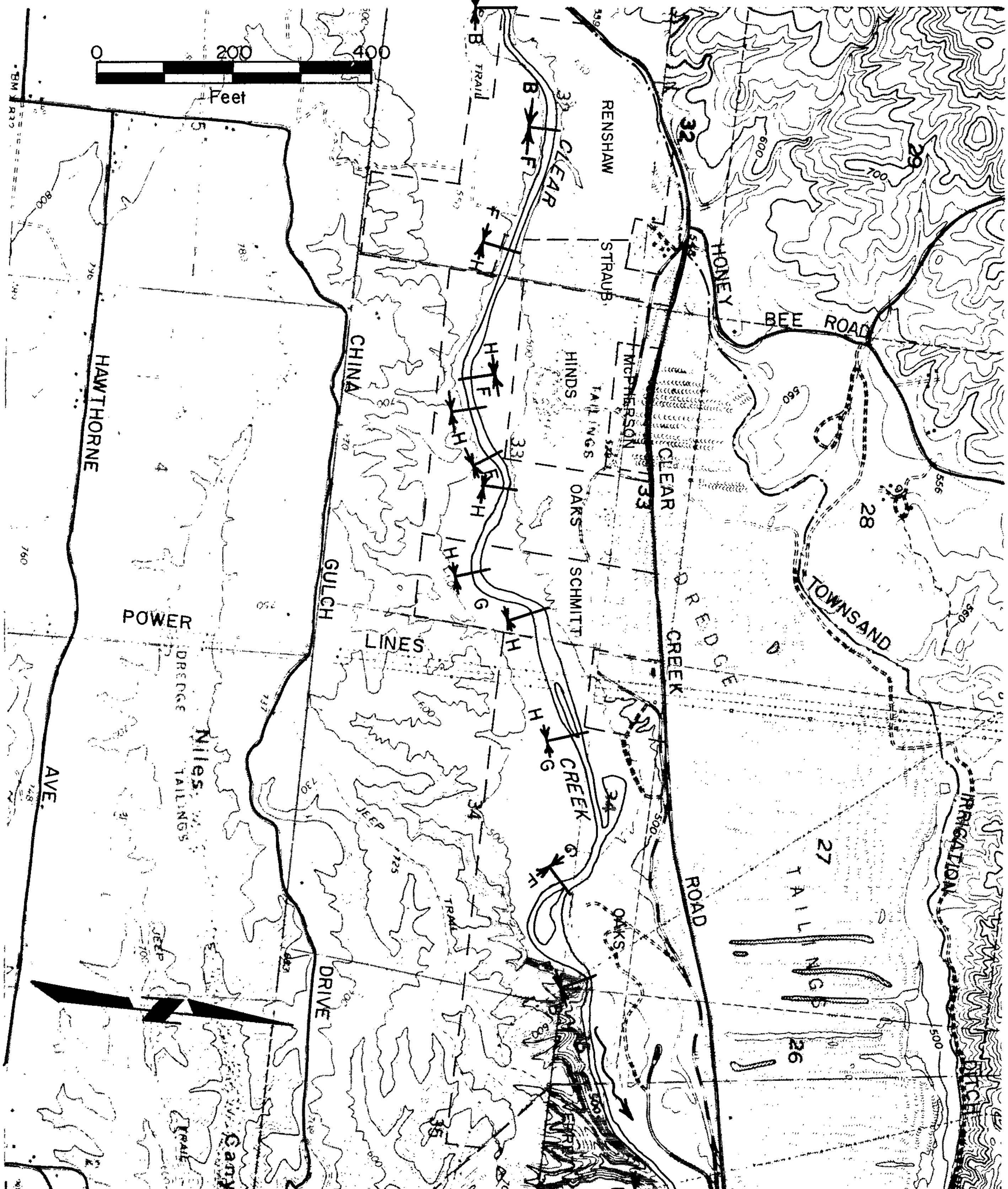

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Plate 3

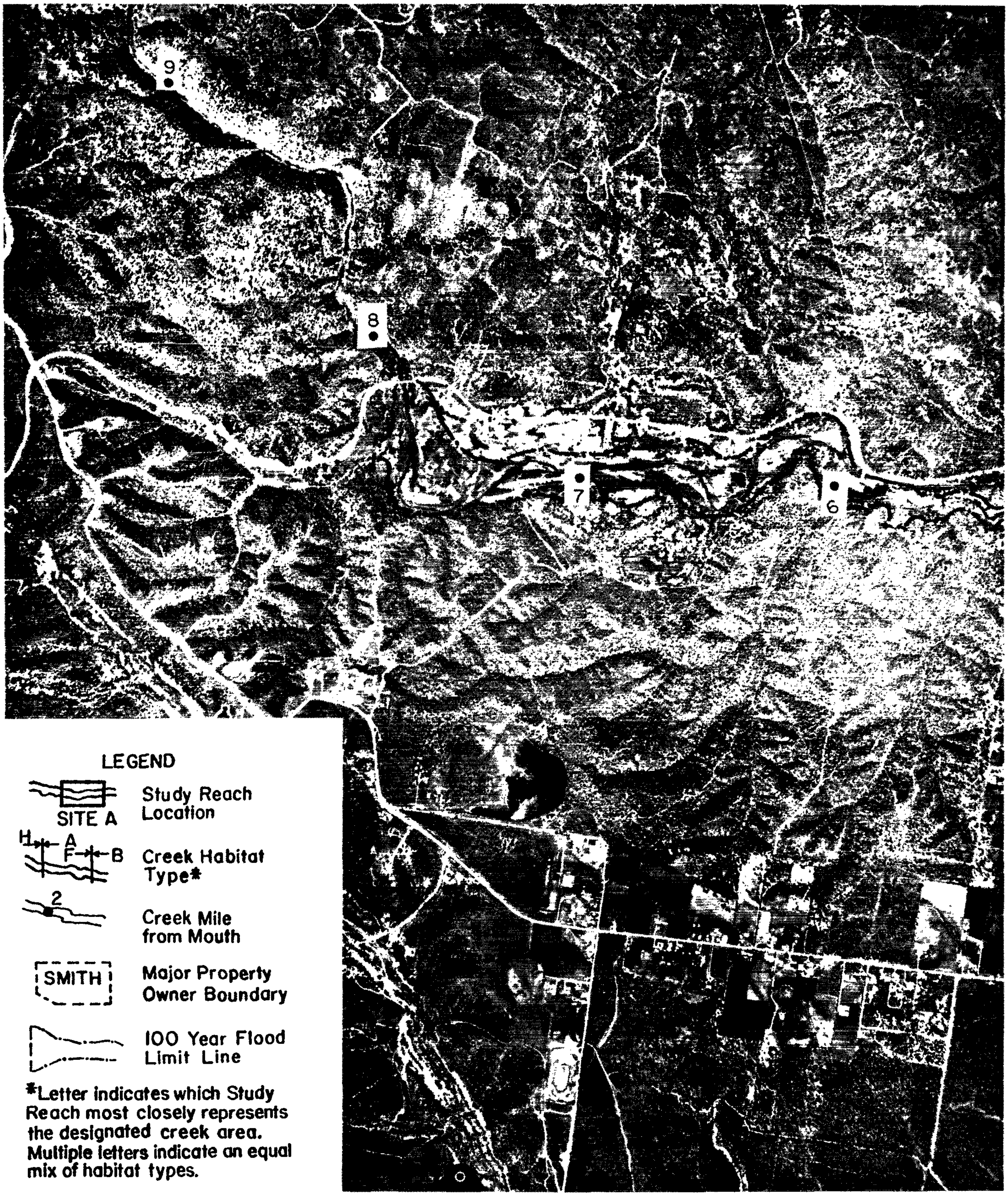
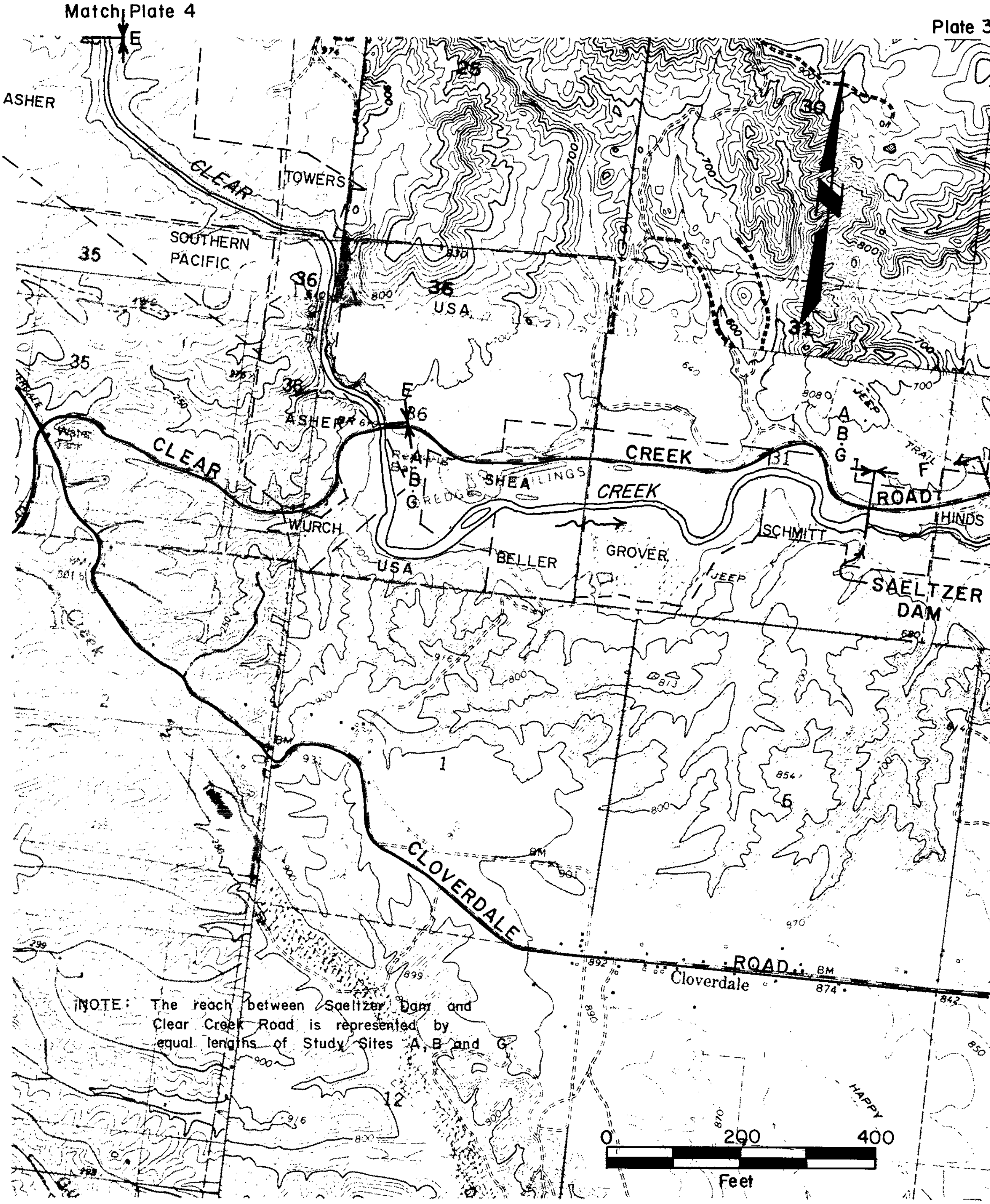

9
8
7
6
LEGEND
SITE A
Study Reach Location
H A F B
Creek Habitat Type*
2
Creek Mile from Mouth
SMITH
Major Property Owner Boundary
100 Year Flood Limit Line
*Letter indicates which Study Reach most closely represents the designated creek area. Multiple letters indicate an equal mix of habitat types.

Plate 3



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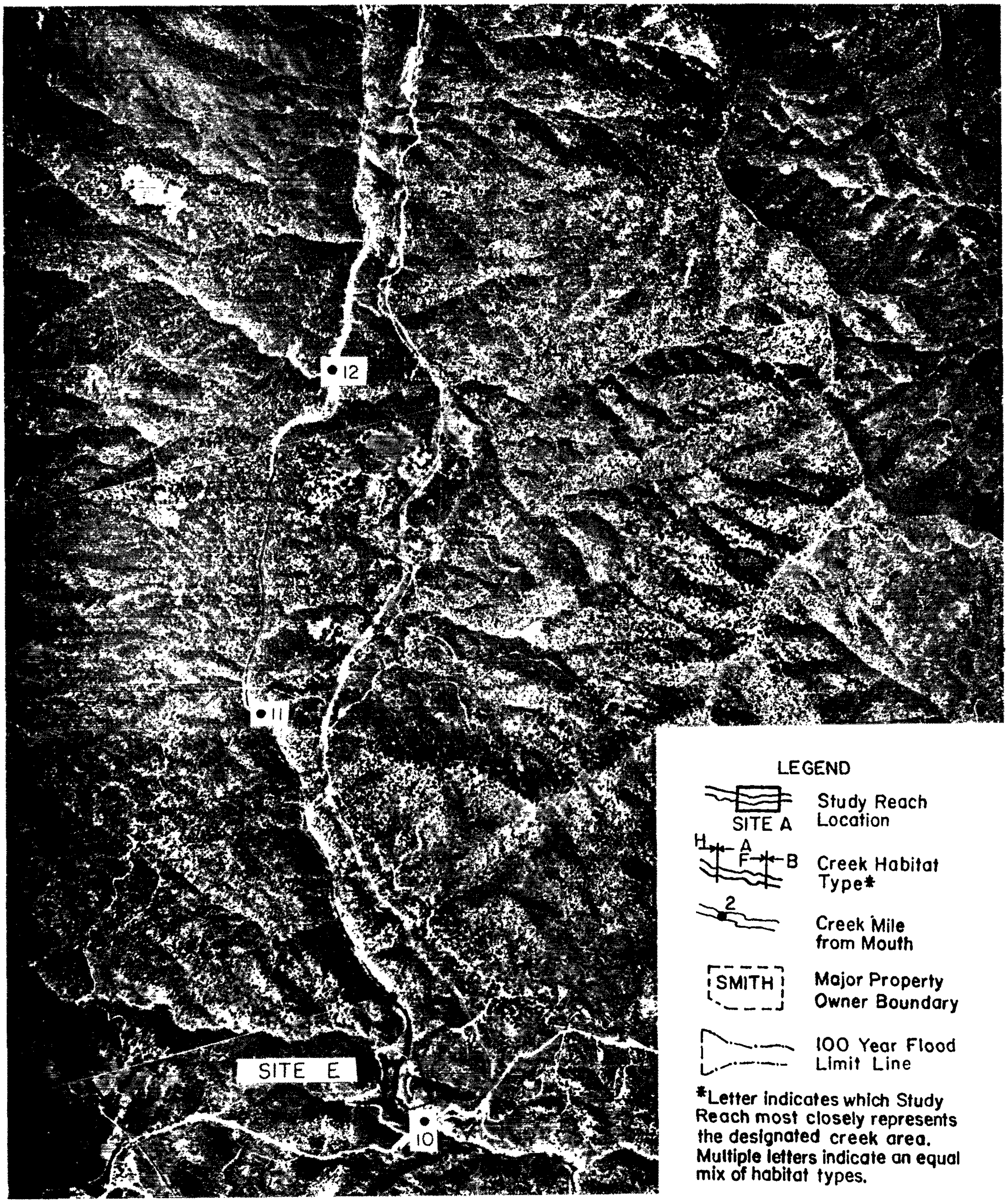
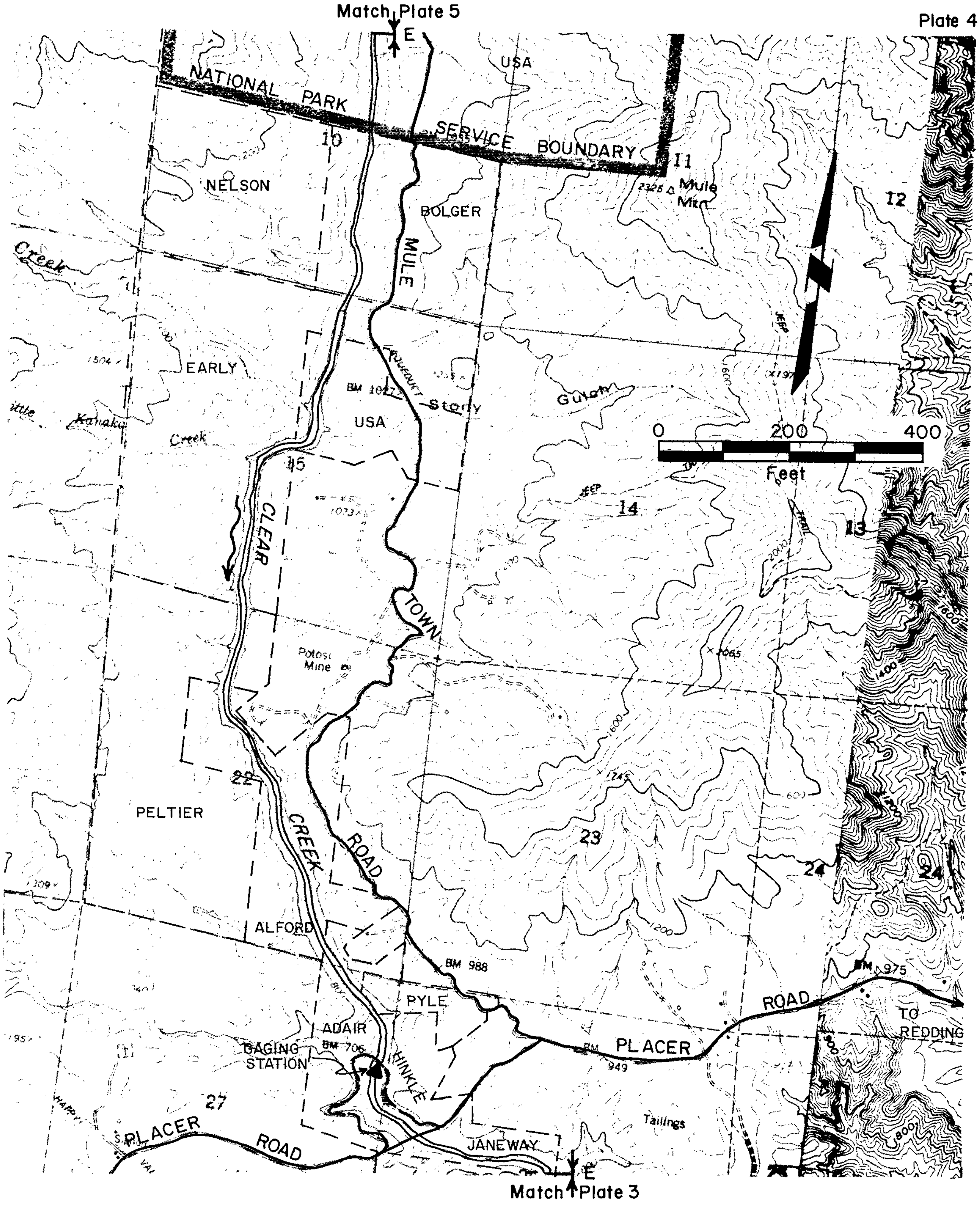

12
11
SITE E
10
LEGEND
SITE A
Study Reach Location
H A F B
Creek Habitat Type*
2
Creek Mile from Mouth
SMITH
Major Property Owner Boundary
100 Year Flood Limit Line
*Letter indicates which Study Reach most closely represents the designated creek area. Multiple letters indicate an equal mix of habitat types.

Plate 4



C —0 6 4 8 2 5

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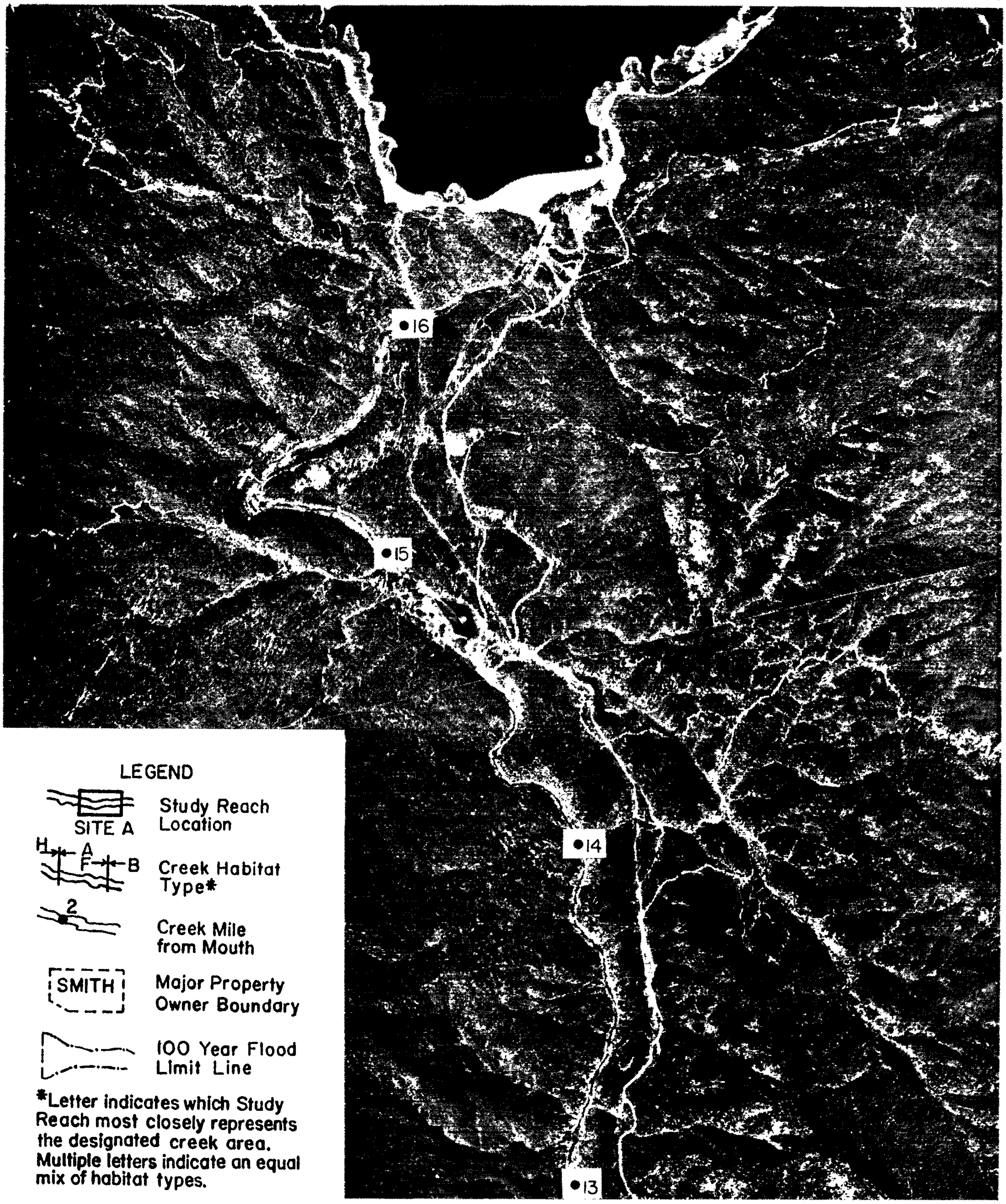
Plate 5


16
15
14
13
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H A F B
Creek Habitat Type*
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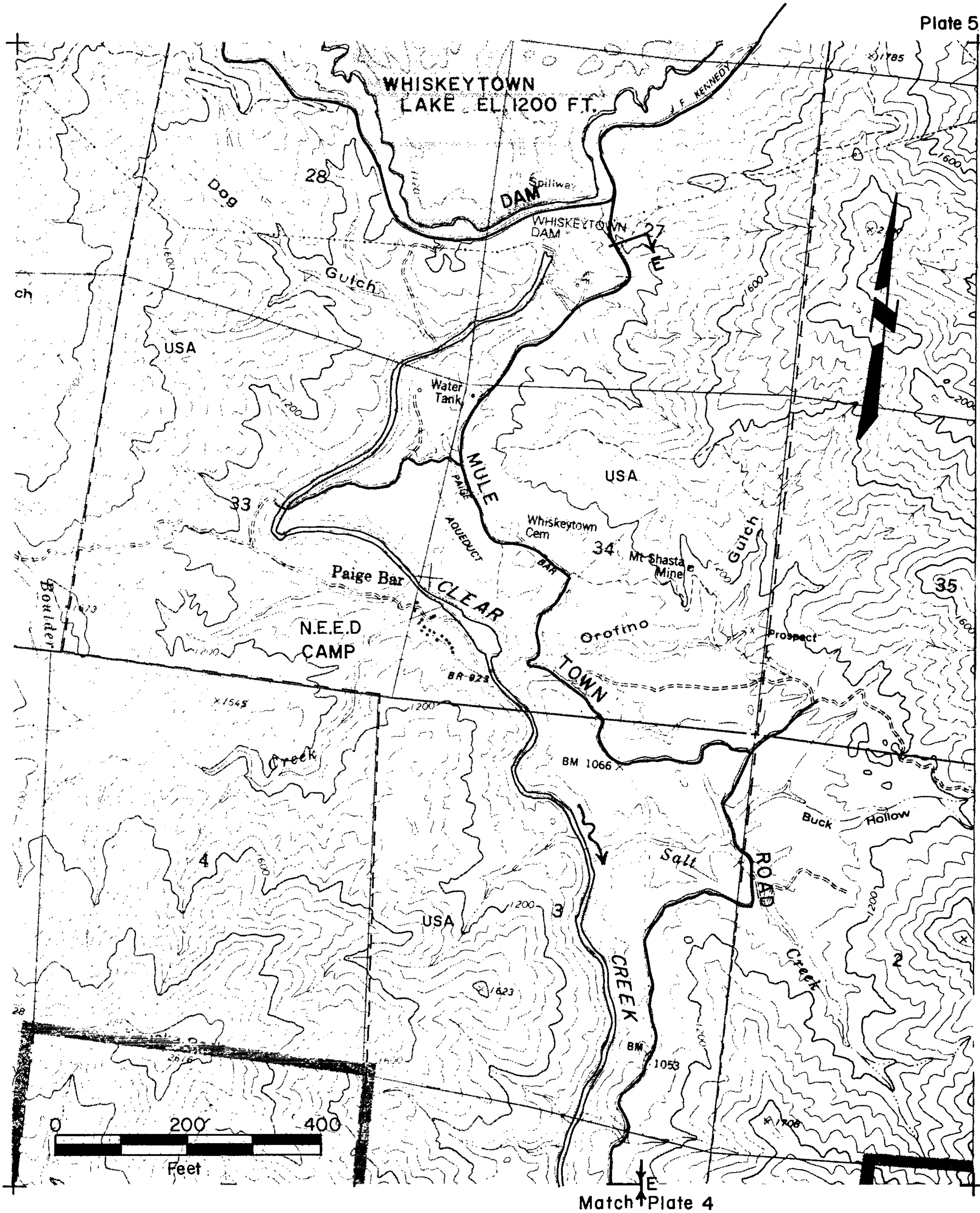
Creek Mile from Mouth
SMITH
Major Property Owner Boundary
100 Year Flood Limit Line
*Letter indicates which Study Reach most closely represents the designated creek area. Multiple letters indicate an equal mix of habitat types.



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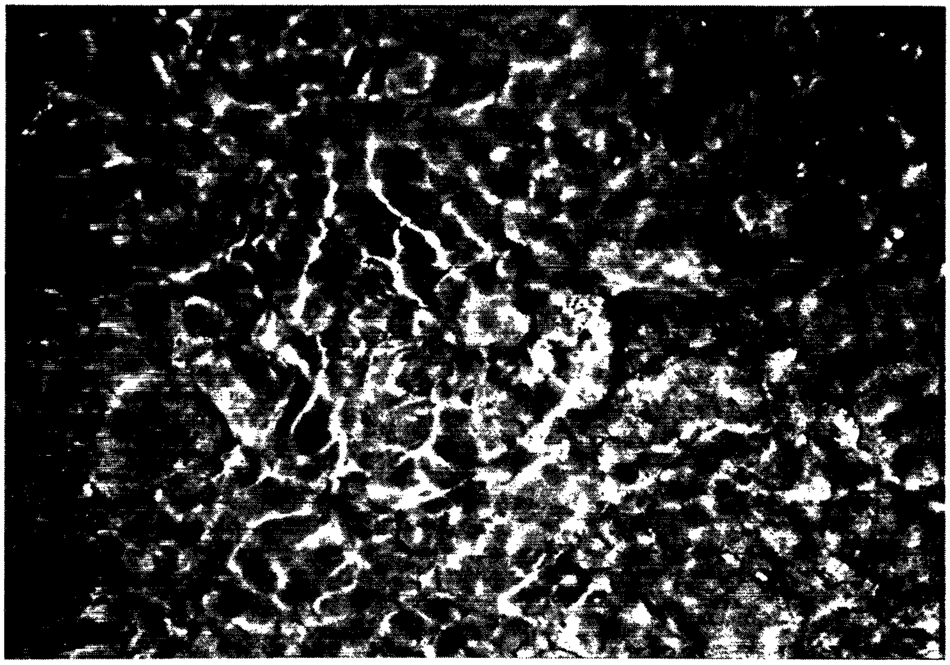


Silted and compacted stream gravels are not usable for spawning or growth of fishfood organisms. Gravels cleansed by ripping (below) would provide better habitat for food-producing organisms and predator-escape habitat for fish fry.

CHAPTER III. FISHERY PROBLEMS AND IMPROVEMENT OPPORTUNITIES

Man's activities in the Clear Creek Basin have resulted in a large decrease in fishery habitat for both Clear Creek and the Sacramento River. However, several rehabilitation actions are possible that would help restore this loss. Chapter III discusses Clear Creek's existing problems and possible solutions.

Sacramento River

During the last 30 years, Sacramento River salmon runs have fallen from a peak of around 400,000 fish to less than 200,000 annually. Similarly, steelhead numbers during the same period have decreased from 20,000 fish annually to less than 10,000 currently. These reductions have adversely affected many economically important user groups, including sport fishermen, the tourist industry, and the commercial fishing industry. Published estimates of the combined total commercial value of the upper Sacramento River salmon fishery run as high as $86 million annually. Presently, Clear Creek produces approximately 2 percent of the Sacramento River salmon and, with rehabilitation work, has the potential to produce 6 percent or more of the total run. This would be equivalent to approximately $5 million in annual economic value to the commercial fishing industry alone.

Causes of the decline in the Sacramento River fishery are numerous. Significant factors include (1) partial migration blockage along with predation at the Red Bluff Diversion Dam, (2) heavy metal pollution from old mine areas near Keswick Dam, (3) and loss of spawning gravels in the river below Shasta Dam. Ongoing efforts will no doubt eventually result in improved fish passage at the Red Bluff Diversion Dam, and resolution of heavy metal pollution and increased spawning areas. Protection and restoration of spawning gravels in Clear Creek would increase spawning and rearing habitat in both Clear Creek and, eventually, in the Sacramento River as gravels are moved downstream during floodflows.

Clear Creek

Clear Creek's importance to anadromous fishery is largely due to its influence on the Sacramento River fishery. The Clear Creek fishery habitat has suffered severe damage during the last several decades. Three primary causes have been identified: (1) loss or degradation of spawning gravels, (2) reduced flows caused by Whiskeytown Dam and water diversions, and (3) blockage of fish passage at Saeltzer Dam.

Loss of Gravels

Gravel mining in the lower 3 miles has removed most of the streamside gravel terraces and artificially relocated a large reach of the stream channel to areas devoid of gravels. Several gravel-extraction pits remain in the creek flood plain. These pits trap much of the downstream-moving sand and gravel. Also, construction of Whiskeytown Dam in 1963 blocked migration of all stream gravels originating in the upper watershed. A 1980 DWR study entitled "Upper

Sacramento River Spawning Gravel Study" found that during the gravel mining period prior to 1980, the annual amount of gravel removed from Clear Creek was roughly 20 times greater than the amount that entered the Sacramento River from Clear Creek.

Highly erosive decomposed granite soils cover about half of the watershed below Whiskeytown Dam. Logging and other land use activities on these soils have resulted in large quantities of sand being washed into the creek channel. In the absence of frequent large winter flushing flows due to control at Whiskeytown Dam, the sand fills gravel voids in the stream channel. This lowers the survival rate of developing salmon eggs, and reduces the stream bottom insect population which provides food for fish. Sediment buildup has narrowed the creek and resulted in the growth of extremely thick riparian vegetation along the banks.

Reduced Flows

Whiskeytown Dam presently diverts approximately 87 percent of the natural flows from lower Clear Creek to Keswick Reservoir. The present Whiskeytown operation schedule provides for a Clear Creek flow release of 50 cubic feet per second (cfs) from January through October and 100 cfs during November and December. These flows are not adequate to provide sediment flushing or attraction for migrating fish.

Whiskeytown Dam, at mile 16.5, permanently blocks upstream-migrating salmon and steelhead. Saeltzer Dam has blocked the migration of salmon and steelhead to spawning and rearing areas above mile 6 since the early 1900s. Attempts to provide fish passage around Saeltzer Dam have not been successful.

In spite of historic damage, the lower 6 miles of Clear Creek still supports a sizable fall run of chinook salmon. As part of our cooperative study on Clear Creek, DFG estimated that about 4,000 fish spawned from October 1981 through March of 1982 and that about 1,000 spawned from October through December of 1983. (Counts after December were not possible due to high water conditions.) The presence of relatively large numbers of salmon in a 6-mile reach of stream which has experienced severe habitat degredation would seem to indicate that the creek would support much larger runs if the habitat were restored and adequate flows maintained.

The potential for instream flow enhancement is discussed in Chapter IV, and opportunitites for habitat-restoration are presented in Chapter V.

Fishery Investigations

The Department of Fish and Game, under contract with DWR, conducted a 2-year fishery study of Clear Creek. Results of this study are contained in a February 1984 report titled "The Potential for Rehabilitating Salmonid Habitat in Clear Creek". This study examined the following elements related to chinook salmon habitat in Clear Creek: (1) population levels of adult salmon, (2) juvenile out-migration, (3) spawning habitat, (4) fish-ladder rehabilitation, (5) artificial propagation, and (6) enhancement techniques. Data from this study are used to develop recommendations for future enhancement and rehabilitation work.

Salmon Population Trend

The estimated average run of fall-run chinook salmon in Clear Creek since 1951 has declined slightly, as shown in Table 1.

From October 1981 through December 1983, 37 weekly counts of salmon in the lower 6 miles of Clear Creek were made during the fall and late-fall runs extending from October through mid-April. During the 1981-82 season, 4,008 spawning fish were estimated from these counts and during the first half of the 1982-83 season, 785 were estimated. The late-fall runs during the 1982-83 season could not be counted due to extremely high flows. Counts made during the 1981-82 season are the most intensive and accurate spawning-use estimates for Clear Creek. Other years of data are shown in Table 1 and are derived from aerial redd counts and carcass surveys. All spawning activity occurred downstream from Saeltzer Dam because it is presently impassable, and most spawning was concentrated from miles 3 to 5 because most of the remaining suitable gravels are located in this reach.

Wet suits and inflatable rafts were used by DFG personnel to survey fish in Clear Creek.

TABLE 1

FALL-RUN CHINOOK SALMON SPAWNING STOCK ESTIMATES FOR CLEAR CREEK FROM THE MOUTH TO SAELTZER DAM, 1951-1982 1/

Year	Survey Trips	Actual Number of Carcasses Counted	Percent Recovery	Estimate
1951	Estimate is based on single aerial survey redd counts			700 2/
1952	Estimate is based on single aerial survey redd counts			550 2/
1953	Estimate is based on single aerial survey redd counts			1,580 2/
1954	No recorded information is available			
1955	-	-	-	1,000 3/
1956	4	530	20	2,650
1957	6	66	20	330
1958	6	313	20	1,600
1959	4	62	8	755
1960	6	116	13	900
1961	No survey	-	-	-
1962	2	1,071	20	5,400
1963	6	1,169	12	10,000
1964	3	718	29	2,500
1965	2	843	34	2,500
1966	5	230	26	900
1967	3	66	18	370
1968	5	280	35	800
1969	3	310	25	1,240
1970-75	No survey	-	-	-
1976	9	152	15	1,013
1977	5	165	12	1,362
1978	2	3	No estimate	
1979	2	75	No estimate	
1980	No survey			
1981	23	701	17	4,008 4/
1982	11	492	63	785 5/

1/ Villa, 1984.

2/ Conducted by U. S. Fish and Wildlife Service (Warner, 1956).

3/ This figure represents an actual count of adult fish planted in Clear Creek that were trapped and trucked from the Keswick trap (Warner, 1956).

4/ Includes late fall-run estimate of 875.

5/ Partial season total; high water conditions ended survey in December.

Spawning Habitat Conditions

The lack of adequate spawning habitat is a major problem contributing to declines in fish populations in the Sacramento River. Much of the suitable gravels between Redding and Red Bluff have migrated downstream during flood-flows, leaving bottom materials that, in most locations, are too large and armored for successful spawning. Suitable gravels are not being naturally replaced because of the blockage at Shasta and Whiskeytown Dams and because many tributary streams, including Clear Creek, have been heavily mined for gravels.

The suitability of gravels in Clear Creek for salmon spawning was investigated in 1982 by analysis of the size composition of streambed samples from thirteen riffles below Saeltzer Dam and five riffles above the dam. Criteria developed by DFG for identifying suitable chinook salmon-spawning gravel are given in Table 2. Results of this gravel screening analysis are shown in Table 3. Samples taken in 1965 by DWR and DFG are also shown.

TABLE 2

DEPARTMENT OF FISH AND GAME CRITERIA FOR IDENTIFYING SUITABLE SPAWNING GRAVEL FOR CHINOOK SALMON1/

Gravel Size (inches)	Allowable Volume (percent)
6-12	30 or less
3-6	10 or more
1-3	50 or less
0.5-1	20 or less2/
0.16-0.5	20 or less2/
0.015-0.16	20 or less2/

1/ Pollock (1969).

2/ The three smaller sizes in combination should not exceed 50 percent (Van Woert and Smith, MS).

TABLE 3

PERCENT GRADATION DISTRIBUTION OF CLEAR CREEK BOTTOM GRAVELS

Date Sampled	Creek Mile	Size Range in Inches: 6-12	3-6	1-3	0.5-1	0.16-0.5	Smaller than 0.16	Meets DFG Criteria
				Below Saeltzer Dam				
1965	3.7	0	20.0	26.7	17.3	19.4	16.6 1/	No
1965	3.7	6.9	17.6	29.3	13.4	16.8	16.0 1/	Yes
1965	3.7	0	34.0	31.6	8.6	11.4	14.4 1/	Yes
1965	3.7	5.0	22.0	27.4	10.9	16.2	18.5 1/	Yes
1982	2.4	0	5	30	13	21	31 2/	No
1982	4.2	0	0	32	19	22	27 2/	No
1982	4.4	0	0	42	13	18	27 2/	No
1982	5.1	0	13	22.5	13.8	12.3	38.4 3/	No
1982	5.2	0	0	32	12	18	38 2/	No
1982	5.2	0	12	29	14	21	24 2/	No
1982	5.2	0	21	25	12	18	24 2/	No
1982	5.2	0	20.5	22.1	11.9	12.1	33.4 3/	No
1982	5.2	0	32.6	20.9	9.7	14.7	22.8 3/	No
1982	5.3	0	15.5	22.2	8.7	10.1	43.5 3/	No
1982	5.3	0	9.3	26.5	13.2	8.2	42.8 3/	No
1982	5.3	0	13	31	15	18	23 2/	No
1982	5.4	11.5	21.4	13.7	9.4	11.5	32.5 3/	No
				Above Saeltzer Dam				
1982	6.5	0	10	36	13	17	24 2/	No
1982	6.6	0	31.9	19.1	9.3	10.3	29.4 3/	No
1982	6.7	0	12.9	24.8	11.6	10.2	40.5 2/	No
1982	6.7	10.4	16.8	18.8	9.2	9.8	35 3/	No
1982	7.6	8.2	17.7	13.7	7.9	13.7	38.8 3/	No

1/ Hinton, unpublished DFG file data.

2/ DWR, unpublished data.

3/ Villa, 1984.

None of the samples taken in 1982 met the DFG criteria, whereas 75 percent of those taken in 1965 did. The 1982 bottom samples contained from 47 to 68 percent sand and silt finer than one-half inch. The combined sand and silt has the following undesirable effects on fish: It (1) compacts the gravels so that nest digging is difficult for the fish; (2) restricts the flow of water through the gravels, thus reducing oxygen to the eggs; (3) fills the void spaces between gravel particles so that emerging fish are trapped; and (4) greatly reduces food production by covering or filling space needed by bottom organisms.

Spawning salmon still attained some degree of success, as shown by a fyke net outmigration study conducted during 1982. In digging their nests (redds), salmon separate some of the sand from the gravels. Even so, cleaner gravels would result in higher hatching rates for deposited eggs.

Comparison of data collected in 1965 and 1982 indicates that the quality of Clear Creek spawning gravel has declined markedly since 1965. This seems logical considering that (1) Whiskeytown Dam blocks all gravel sources above mile 16.5, (2) 87 percent of the natural flow of Clear Creek is diverted from the creek at the reservoir and (3) approximately half of the creek watershed below the dam is comprised of decomposed granite soils. Other studies substantiate this fishery habitat degradation following the construction of Whiskeytown Dam. DFG biologist George Warner in 1956 estimated the salmon-carrying capacity of Clear Creek above Saeltzer Dam at around 6,000 salmon annually. Later work by DFG biologist Millard Coots (unpublished) determined that for this same area, 93 percent of the spawning gravels were lost during the years following completion of Whiskeytown Dam (Table 4).

TABLE 4

COMPARISON OF SALMON-SPAWNING HABITAT CHANGES ON CLEAR CREEK FROM 1956 TO 1970*

Section by River Mile	Usable Spawning Area (ft^2) 1956 Survey	Usable Spawning Area (ft^2) 1970 Survey	Change from 1956 to 1970
11.6-10.6	89,995	7,804	-91%
10.6-10.0	86,604	4,004	-95%
10.0- 5.6	39,104	3,595	-91%
5.6- 4.3	131,596	8,815	-93%
Total	347,299	24,218	-93% (average)

*Coots, unpublished DFG file data.

Other significant findings resulting from study of present and past habitat conditions follow:

1. Virtually all of the stream areas below Saeltzer Dam with suitable depth, velocity, and bottom gravel (substrate) conditions were utilized for spawning during the 1981-82 season. Therefore, spawning habitat apparently limits the number of salmon produced in Clear Creek.

2. Most spawning occurs between miles 3.0 and 5.5, which contain the majority of remaining suitable spawning gravels.

3. No anadromous fish were observed above Saeltzer Dam.

4. Many areas in lower Clear Creek have suitable depth and velocity for salmon spawning and rearing, but the bottom material is unsuitable. These areas could be rehabilitated by cleaning (ripping) existing gravels and by placing additional screened gravels in the stream channel. Low weir structures (gabions) would be used to keep the new gravel in place.

Fish Passage Problems

Several potential barriers to anadromous fish migration exist on Clear Creek. The first is the 4-foot-high sheet piling dam at mile 1.2, constructed by the U. S. Bureau of Reclamation to protect the Anderson-Cottonwood Irrigation District Canal's inverted siphon that crosses Clear Creek. Even though it appears imposing, the stepped spillway in the center, combined with a deep plunge pool, does not appear to significantly hinder fish passage.

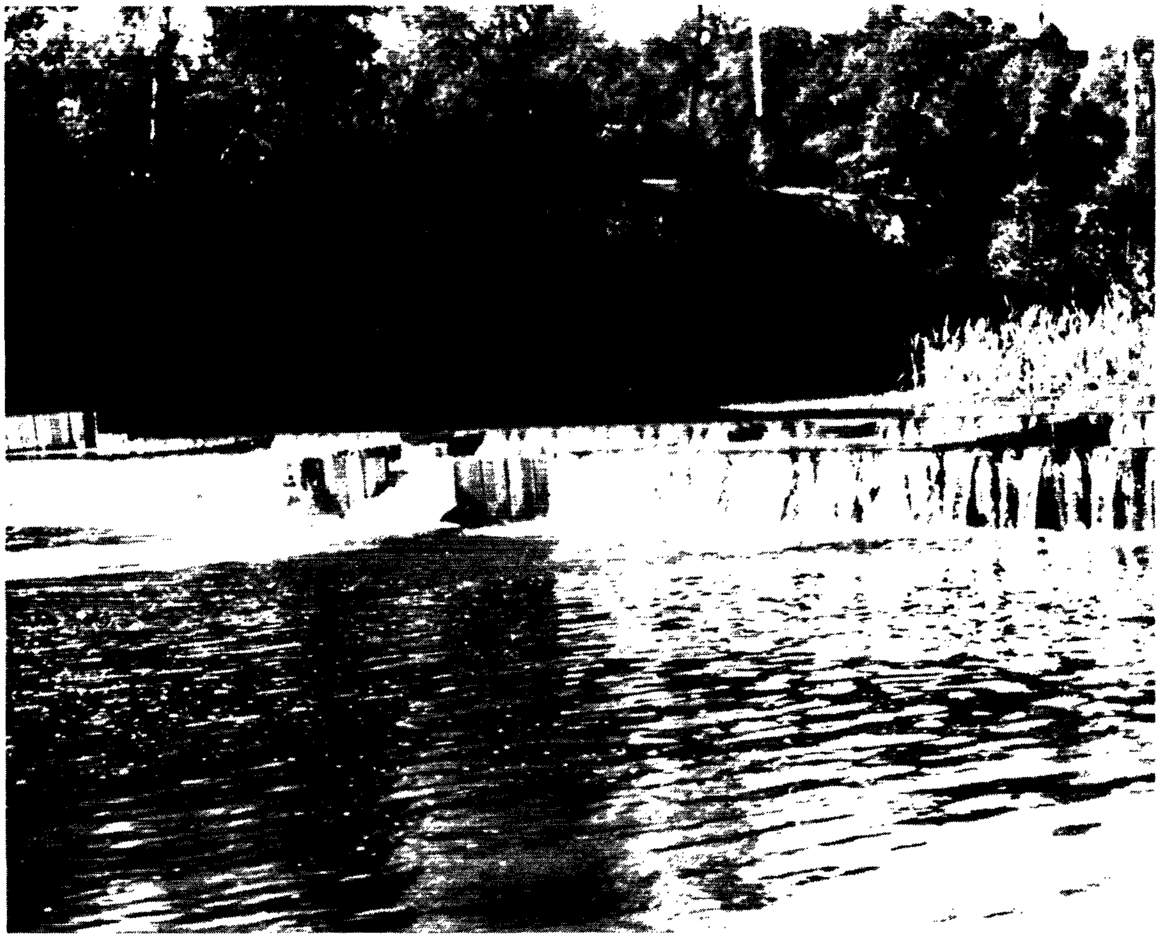
The 15-foot-high Saeltzer Dam at mile 6.0, built in 1903 to divert water through the Townsend Ditch for mining and irrigation, is a total fish barrier. Even though fish-passage structures were constructed around the dam, they were never successful. The existing fish-passage structure, a 370-foot-long tunnel ladder constructed in 1958, consists of a series of pools ascending 41 vertical feet around the right dam abutment. This ladder has not been maintained for several years and is presently inoperable. During operation, the following major problems prevent it from attracting and passing fish:

1. The upstream water entrance to the ladder is easily blocked by accumulated sediment.

2. The downstream fish entrance is positioned in a low-velocity backwater area, and although the maximum design flow is 15 cfs, usual flows do not create enough velocity to attract fish.

3. The tunnel is dark, which may discourage fish from entering.

4. The ladder is difficult to maintain due to limited access and somewhat hazardous conditions inside.



The sheet piling dam at the Anderson-Cottonwood Irrigation District siphon crossing is not considered a barrier to fish passage.

A proposal has been made by Phil Warner of the DFG Redding office to construct an open pool and weir ladder from the plunge pool immediately below the dam right abutment. This would connect into the upper 50 feet of the existing ladder.

In addition to the new section of ladder, the area around the water entrance to the existing ladder needs to be cleaned of sediment and vegetation, and a rock fish-passage barrier immediately below Saeltzer Dam should be removed. If this ladder can be made operational, it would open up an additional 2 miles of salmon-spawning and rearing habitat similar to that below the dam. It would also make 10 miles of steelhead habitat accessible. Summer water temperatures in the first 8 miles below Whiskeytown Dam are acceptable for steelhead rearing under the existing water release schedule of 50 cfs. Larger summer flow releases would extend suitable temperatures downstream.

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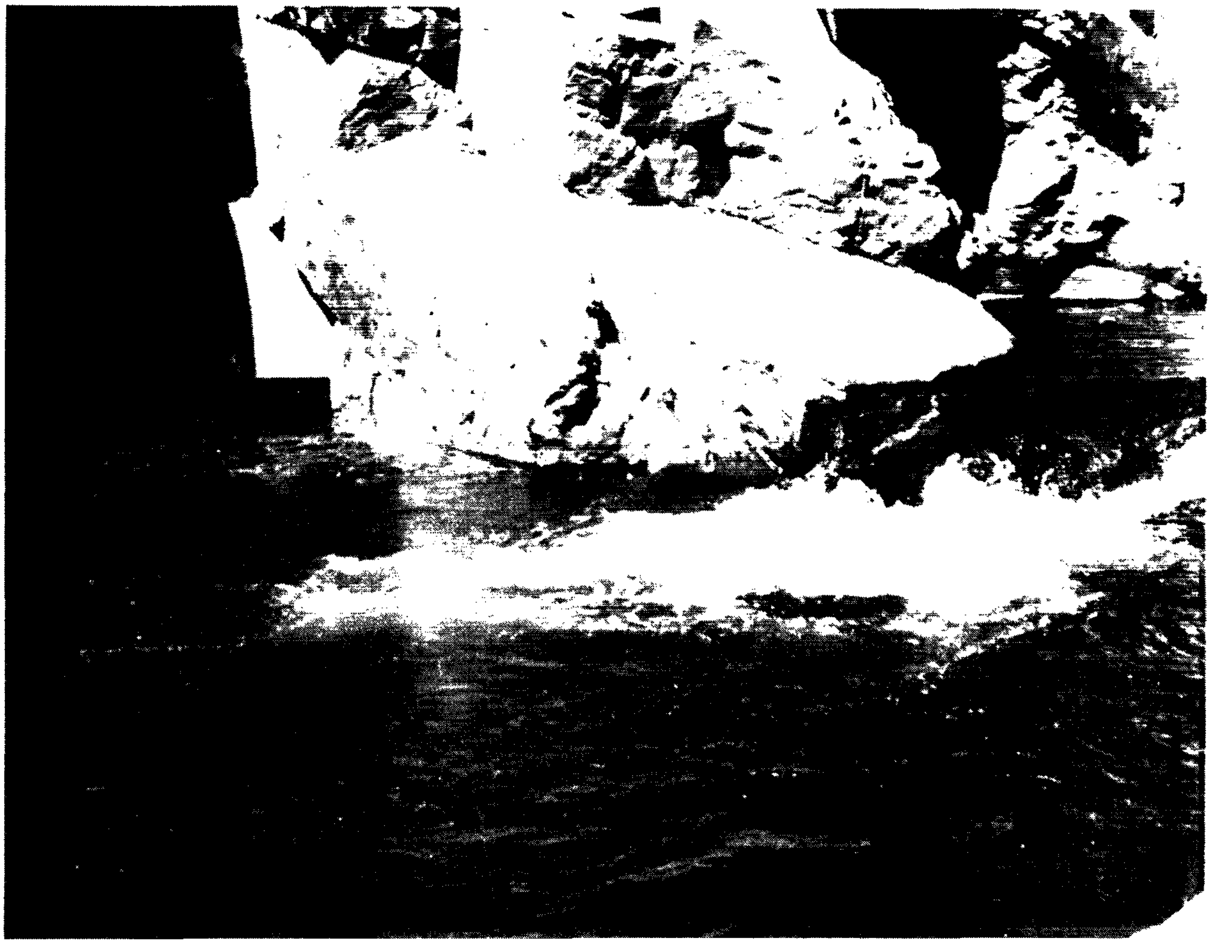


The concrete structure on the left is the downstream entrance to the inoperable Saeltzer Dam tunnel-type fish ladder.

Juvenile Chinook Emigration

To determine the timing and condition of out-migrating chinook salmon, a fyke net was placed near the mouth of Clear Creek. The net was in place continuously from January 27 through June 11, 1982, except during weekends and extremely high flows. Captured fish were counted and fork lengths of a representative sample were measured. No attempt was made to estimate the total number of out-migrating fish. Juvenile salmon were caught the first day of sampling, which demonstrated that out-migration began prior to January 27. Weekly fish counts did not correlate well with either flow level or water temperature.

The average length of out-migrants was 1.5 inches. This work demonstrates that significant numbers of young salmon migrated out of Clear Creek to the Sacramento River from mid-January through early June. Therefore, even though the stream gravels are heavily laden with sand, they are still capable of supporting some successful egg incubation and hatching.

Survey of Resident Fish Species

During the fall of 1981 and the spring of 1982, resident fish surveys of small riffles and pools in Clear Creek were made by DFG personnel using a backpack electroshocker. Larger pools were sampled with a boat electroshocker or seine net. The survey was conducted to determine the variety of fish species, not to estimate population.

Twenty-two species of fishes were observed (Table 5). The most abundant nongame fish found above Saeltzer Dam were sucker, squawfish, and prickly sculpin, while the most abundant game species were rainbow trout and bluegill. Below the dam the most abundant nongame fish were sucker, squawfish, and hardhead, while bluegill and green sunfish were the most abundant resident game fish. Large and smallmouth bass were also present in large numbers.

TABLE 5

FISHES OBSERVED IN CLEAR CREEK[1]

Common Name	Scientific Name	Above Saeltzer Dam	Below Saeltzer Dam
Pacific lamprey	*Lampetra tridentata*	NF[2]	A[2]
Chinook salmon	*Oncorhynchus tshawytscha*	NF	C
Rainbow trout	*Salmo gairdneri*	C	U
Steelhead	*Salmo gairdneri gairdneri*	NF	U
Speckled dace	*Rhinichthys osculus*	A	U
Carp	*Cyprinus carpio*	C	A
California roach	*Lavinia symmetricus*	U	C
Hitch	*Lavinia exilicauda*	U	U
Hardhead	*Mylopharodon conocephalus*	C	A
Sacramento squawfish	*Ptychocheilus grandis*	A	A
Sacramento sucker	*Catostomus occidentalis*	A	A
White catfish	*Ictalurus catus*	U	U
Black bullhead	*Ictalurus melas*	C	C
Brown bullhead	*Ictalurus nebulosus*	C	C
Mosquitofish	*Gambusia affinis*	A	A
Threespine stickleback	*Gasterosteus aculeatus*	C	C
Green sunfish	*Lepomis cyanellus*	C	C
Bluegill	*Lepomis macrochirus*	A	A
Smallmouth bass	*Micropterus dolomieui*	C	C
Largemouth bass	*Micropterus salmoides*	C	C
Tule perch	*Hysterocarpus traski*	U	C
Prickly sculpin	*Cottus asper*	A	C

1/ Villa, 1984.
2/ A = Abundant, C = Common, U = Uncommon, NF = Not Found

Most of these fish prey on or compete for food and cover with juvenile salmon and steelhead. Some management techniques, such as trapping predators or manipulating creekflows to disfavor predator fish, could be implemented but probably are not justified. For example, if Clear Creek were to be managed solely for chinook salmon production, the creek could be dried up during the summer to eliminate predators. However, this would also eliminate aquatic insects, summer recreation use, and the potential to rear steelhead in the lower reaches of the creek. For these reasons, no recommendations are made in this report to control predator species. Control of predator species should be investigated further as part of the monitoring and evaluation of future fishery rehabilitation work on the creek.

Artificial Propagation

Clear Creek has received cursory investigation in the past to determine its potential to support a fish hatchery, rearing ponds, or artificial spawning channel. Following is a discussion of opportunities for each.

Fish Hatchery

Because of the excellent quality and quantity of Clear Creek flows immediately below Whiskeytown Dam and the sizeable run of chinook salmon presently using the lower creek, the upper portion of the stream would appear to have good potential for a hatchery. However, two significant problems must be solved before a hatchery could be built:

1. There is a deficiency of flat areas along the creek on which to locate a hatchery. The only suitable location above Saeltzer Dam is presently occupied by an environmental education camp, although it might be possible to locate both facilities in the same area. A hatchery could be located in the area immediately below Saeltzer Dam, provided streamflows are increased sufficiently to assure suitable summer water temperatures.

2. Fish passage problems at Saeltzer Dam and at several natural falls between Saeltzer and Whiskeytown Dams must be solved before adult fish could return to an upstream hatchery.

The recent discovery (fall 1985) of whirling disease in the Coleman National Fish Hatchery on Battle Creek may greatly increase the need for a steelhead hatchery on Clear Creek.

For many years, Coleman Hatchery has been the major source of steelhead in the Sacramento River above Red Bluff. However, as a result of the outbreak of whirling disease, no steelhead will be produced at Coleman Hatchery for at least 2 years, and possibly much longer. Therefore, studies should be undertaken to determine if all or part of the Coleman steelhead production should be moved to Clear Creek.

Following are some potential reasons why construction of a steelhead hatchery on Clear Creek may be more advantageous than rebuilding Coleman.

1. Coleman Hatchery is 43 years old and outdated. A new hatchery may be less costly than rebuilding the old one.

2. Battle Creek is subject to continued contamination from upstream sources (hatcheries, etc.).

3. Clear Creek is assured of an adequate supply of cold, clear water at all times, while Battle Creek flows are quite variable.

4. A Clear Creek water supply is not affected by drought, floods, and turbidity, except on very rare occasions.

5. Spawning and rearing of salmon and steelhead at separate hatcheries in separate stream systems might result in better conditions for both species (disease control, temperatures, growth, etc.).

Rearing Ponds

Rearing ponds to raise yearling chinook salmon or steelhead for release as smolts could also be located below Whiskeytown Dam or below Saeltzer Dam. Rearing ponds would require an egg-taking and incubating facility, or importation of juvenile fish from an existing facility. DFG has investigated construction of a temporary swimming pool-size rearing pond at the environmental camp below Whiskeytown Dam. Fish raised at this pond would be released in Clear Creek to initially "seed" the creek. However, before a more permanent rearing pond is located on the creek, adequate spawning habitat should be constructed to provide for natural spawning of returning adults. The use of rearing ponds would be considered an interim measure until the number of fish returning to the creek increased adequately. After a few years, the main creek channel would support the increased run size and the rearing ponds could be removed.

Artificial Spawning Channels

A chinook salmon-spawning channel along lower Clear Creek, north of the county road, was proposed by the Greater Redding Chamber of Commerce Fish and Game Committee in a 1971 report, but a source of funds for its construction was never identified. Presently, artificial spawning channels are not viewed as favorably as they were a decade ago because the constructed channels have not produced as many fish as expected. Most recent fishery rehabilitation work on the Trinity River and other locations has consisted of attempts to improve habitat conditions within the existing stream channel rather than construction of artificial channels.

Steelhead Enhancement

Chinook salmon juveniles begin their seaward migration soon after emerging from the gravels, and therefore are not dependent on sustained summer flows. Consequently, opportunities for improving chinook salmon are available on almost any stream tributary to the Sacramento River, even though the stream may become entirely dry during the summer. Steelhead, on the other hand, must remain in fresh water for at least one full year (and often two or three) before migrating to the ocean (Moyle, 1976). Opportunities for increasing steelhead runs on tributaries to the Sacramento River are therefore extremely limited. However, due to sustained year-round flows below Whiskeytown Dam, Clear Creek is the only tributary on the west side of the Sacramento Valley with significant potential for producing steelhead. Although steelhead runs in Clear Creek are thought to be small, some local landowners have reported catching limits of large trout which may have been anadromous steelhead. Therefore, all reasonable opportunities for increasing steelhead populations should be thoroughly evaluated.

Opportunities for increasing steelhead populations in Clear Creek are limited by three factors: summer water temperatures, blockage by Saeltzer Dam, and suitable spawning and rearing habitat. All of these limitations are correctable, as discussed below:

1. Suitable temperatures could be accomplished by releasing additional summer flows into Clear Creek from Whiskeytown Dam.
2. Blockage could be solved by reconstructing the existing fish ladder at Saeltzer Dam.
3. Degraded habitat could be restored by cleaning existing gravels and by adding clean, graded spawning gravels.

The recommended flow release schedule in Chapter IV will provide near-optimum water temperatures for steelhead above Saeltzer Dam and would maintain acceptable temperatures for some distance below Saeltzer Dam. Funds to reconstruct the fish ladder at Saeltzer Dam have been budgeted by DFG, and construction will probably begin during the summer of 1986.

Habitat in the upper reaches of the creek could be restored by selectively placing screened gravels at available access points and allowing them to be distributed by high winter flows. Also, spawning and rearing areas could be constructed at numerous locations, and held in place by gabions or other control structures.

Water Quality

For salmon and steelhead to thrive in a stream system, the quality of the water must be within certain limits of temperature, turbidity, chemical purity, acidity, and oxygen content. During 1981 and 1982, DWR established 16 water quality monitoring stations from Whiskeytown Reservoir to the Sacramento River. Sampling and monitoring at these stations were used to determine the quality of Clear Creek water as related to fishery use. Complete results of this work are contained in a separately published 1982 DWR memorandum report, which is summarized below.

Chemical analysis of the water revealed several heavy metals, including copper, zinc, and selenium, in concentrations that could be potentially detrimental to fish life under certain conditions. However, most of the water samples that contained near-threshold amounts were collected during low-flow summer months when chemical concentrations were highest. On the basis of these data, it does not appear that heavy metal concentrations are presently detrimental to fish life although additional testing should be performed periodically to assure acceptable limits.

Summer water temperatures were continuously monitored with recorders at the following four locations: (1) Paige Bar, mile 14.7 (Plate 5); (2) Placer Road crossing, mile 10 (Plate 4); (3) Little Mill Road, mile 4.6 (Plate 2); and (4) near the mouth, mile 1 (Plate 1). Salmonids are coldwater fish which experience stress when water temperatures rise above 66 degrees F and will normally die when temperatures exceed 80 degrees F for prolonged periods. Salmon are not present in Clear Creek during the summer months, but steelhead would have to either stay in the stream or move to the Sacramento River when temperatures became too warm. Therefore, the possibility of improving Clear Creek fishery habitat for steelhead would be largely controlled by summer water temperatures.

At the existing summer flow release of 50 cfs from Whiskeytown Dam, higher-than-suitable water temperatures occur in the lower reaches during most summer months, and maximum water temperatures occur during August. Peak water temperatures reached 60 degrees F at Paige Bar, 65 degrees F at Placer Road, 79 degrees F at Little Mill Road, and 82 degrees F at the mouth. These data show that the majority of water warming occurs between creek miles 8 and 5, where the stream exits from a steep, shaded canyon to an open, flat valley terrain.

During August, maximum water temperatures increase at the rate of 0.85 degrees F per mile from Paige Bar to Reading Bar (located 2 miles below the Placer Road bridge at the end of the shaded canyon terrain) but are estimated to warm approximately 3.7 degrees F per mile in the 3-1/4 mile-reach from Reading Bar to the Little Mill Road temperature station. Along the 4 miles from Little Mill Road to near the mouth, the stream heats at the rate of 0.91 degrees F per mile. This lowered heating rate is probably because the water reaches nearly ambient (maximum potential) temperature by the time it reaches the Little Mill Road station.

In July of 1982, the U. S. Bureau of Reclamation made experimental flow releases from Whiskeytown Dam of 150 and 300 cfs for seven days each to assist DWR in monitoring the variable impacts of water velocities, depths, and temperatures on fishery habitat. Water and air temperatures were measured during this period. A summary of summer water temperatures vs flow levels for the lower 16 miles of Clear Creek is shown in Figure 4. Higher flows produced lower stream temperatures at most locations, particularly below Saeltzer Dam. However, these higher flow releases were made during a period of below-normal air temperatures. The lack of greater temperature spread between the 150 cfs and 300 cfs releases is probably due to the relatively cool air temperature (90 degrees F maximum) during the 150 cfs release. Future high-flow temperature measurements will be made in cooperation with the Bureau of Reclamation to obtain more typical summer data.

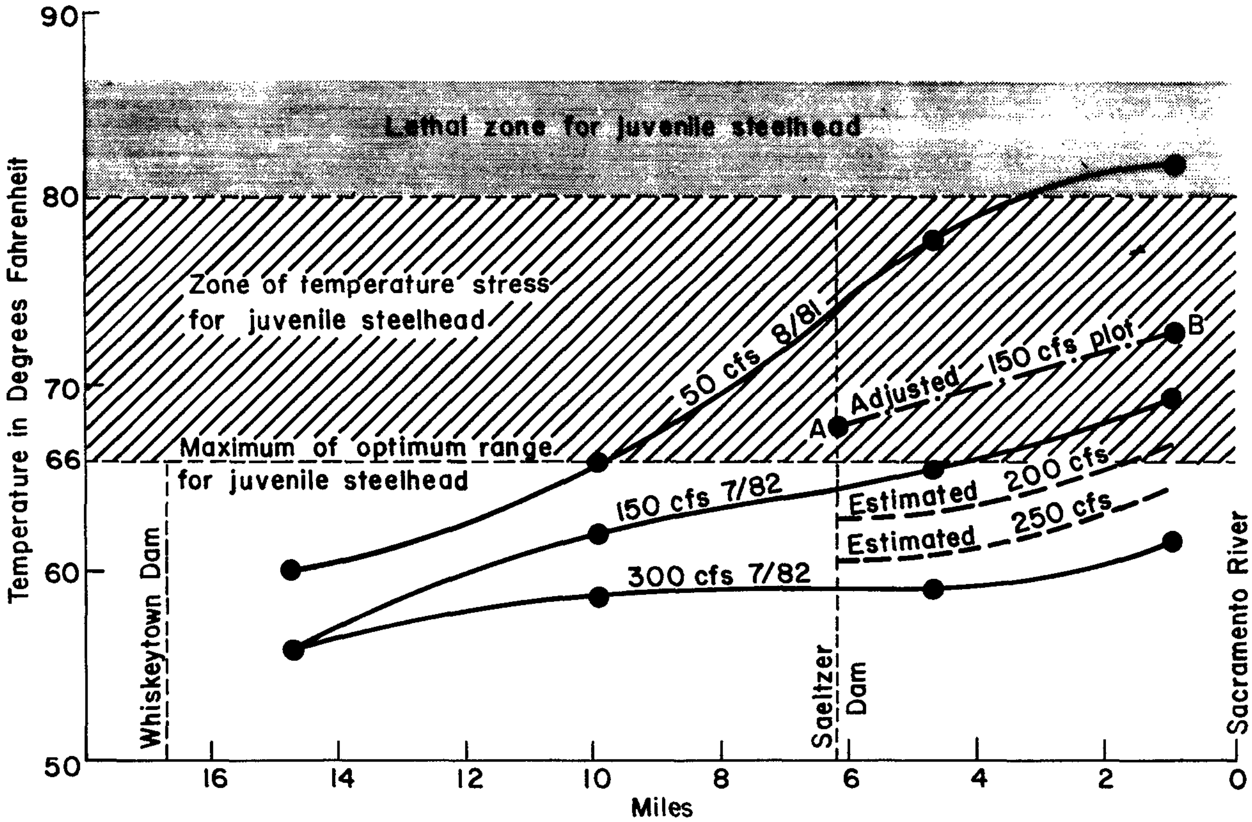
Data indicate that at flows of 150 cfs, maximum daily water temperatures between Saeltzer Dam and the mouth ranged from 61 degrees F to 71 degrees F during August 1982, while flows of 300 cfs resulted in temperatures between 58 degrees F and 64 degrees F. Temperatures below Saeltzer Dam at 150 cfs are at the upper limit of the acceptable range for salmonoids, while water temperatures at 300 cfs fall within the optimum range at all locations. Water temperatures above Saeltzer Dam are generally adequate for salmonoid rearing at present summer flows of 50 cfs, but this area is presently inaccessible to anadromous fish due to blockage of the dam. Cooler water temperatures below Saeltzer Dam are critical only if steelhead are to be encouraged to rear in this reach. If Clear Creek is to be managed primarily for salmon production, or if a fish ladder at Saeltzer Dam is successful at passing steelhead, cooler summer temperatures below the dam are less important.

Numerous samples taken on Clear Creek show that turbidity levels are relatively low and that clearing after a storm is normally rapid. Whiskeytown Reservoir probably acts to reduce turbidity levels in the creek. Also, most of the inflow to the reservoir comes from the Trinity River, which normally produces clear water.

Continuous water quality measurements were made at eight stations in September 1981. Measurements included stream and air temperature, dissolved oxygen, and pH. All monitored stations produced acceptable water quality conditions.

Stream bottom-dwelling insects (benthic microinvertebrates) were collected from eight representative riffles on May 21, 1982. All sample stations contained a variety of species, (stoneflies, mayflies, caddisflies) that are generally intolerant of organic pollution. However, the population levels of these organisms were quite low probably due to a combination of recent high winter flows and a high percentage of granitic sand in the streambed gravels. This sand fills the void areas within the gravel, reducing living space for organisms, and is very abrasive when it moves during high flows. Additional benthic samples should be taken at various times of the year to obtain a more reliable estimate of food production in Clear Creek.

Figure 4



NOTE: This 150 cfs curve data was collected during an abnormally cool summer weather period. Line A-B is an adjustment to a portion of this curve to more closely approximate normal year conditions.
Additional temperature data will be collected to verify this adjustment.

Maximum observed summer water temperatures vs flows along Clear Creek below Whiskeytown Dam.

Water samples were collected from various depths in Whiskeytown Reservoir. Dissolved oxygen levels were in the normal range. The reservoir exhibits a typical temperature distribution vs. increasing depth with the greatest temperature variation occurring during summer. In August, surface water temperatures reach a maximum of around 75 degrees F, with bottom temperatures of 52 degrees F at a depth of about 150 feet. Flow releases to Clear Creek from the reservoir can be made from two outlets, one at elevation 972 feet (238 feet deep) and the other at elevation 1,110 feet (100 feet deep). At present, releases are made from both elevations simultaneously to achieve desired temperatures in Clear Creek. Aeration of this released water at the outlet works ensures that oxygen saturation is near 100 percent.

Recreation

Clear Creek historically receives a substantial amount of summer recreation use, which has increased with the area's population. The most frequent recreational activities are swimming, sunbathing, relaxing, and fishing.

Clear Creek is nearly all privately owned, and most areas are posted against public use. However, this posting does not effectively stop recreation use, which concentrates in areas closest to the road. The areas of greatest use are as follows:

1. The 1-mile reach between the creek mouth to just above Highway 273 bridge crossing is accessible from the bridge or from the City of Redding recreational access easement near the mouth. Bass and trout fishing occur in this reach, and swimmers are attracted to a deep pool below the highway bridge. Some illegal salmon snagging may occur upstream of the bridge during the winter.

2. & 3. The next two areas of significant use are near Saeltzer Dam between stream miles 5.5 and 6. The majority of recreational use along the creek occurs here. The area immediately below Saeltzer Dam is dominated by a deep, rock-walled canyon containing several deep pools that are ideal for swimming. The canyon hides this area from public view, although it is easily accessible from nearby Clear Creek Road. Because of its visual isolation, some nude bathing occurs in the canyon. The small reservoir behind Saeltzer Dam receives considerable summer recreation use. Some overnight camping use occurs here, although there are no sanitation facilities to accommodate it. Recently, the property owner blocked the access road to this dam and posted the area so future recreation use may be reduced.

4. The Reading Bar area, which is 2 miles upstream from Saeltzer Dam, is accessible by the upper Clear Creek Road bridge. Moderate swimming and sunbathing use occur at this location, which is the dividing point between the creek's canyon (upstream) and valley (downstream) terrain.

5. A private recreation club owns property immediately above the old Placer Street road bridge at the mouth of the South Fork of Clear Creek. A sandy beach and deep pools in this area are used for sunbathing and swimming.

Clear Creek can provide scenic recreation near the Redding-Anderson urban area.

6. The federally operated National Environmental Education Camp is located at Paige Bar approximately 1.5 miles below Whiskeytown Dam. Students from surrounding schools attend this camp. Associated recreation use includes hiking, tubing, and fishing. The water is normally too cold in this area for prolonged swimming.

A recreation use survey of the entire creek below Whiskeytown Dam was conducted by DWR from July through September of 1980. Methods used were aerial counts, individual user counts, user interviews and creel censuses. Data results indicate that total recreational use from May through September is in the range of 15,000 recreation user days. Most use is on the weekends (72 percent), and most use is by local residents (85 percent). The major activities are relaxing (42 percent), beach use (26 percent), and swimming (23 percent). Camping, fishing, picnicking, hiking, and tubing combined account for 7 percent of the total use.

Some potential conflicts related to continued recreational use of Clear Creek exist in the lower four areas between the mouth and the upper Clear Creek Road bridge. All accessible creekside areas in this reach receive significant summer recreational use. This would seem to indicate that the presently inaccessible creek reaches would also be used if they were made available for public use. The present use is on private lands without the owner's permission and is therefore subject to closure.

Most owners want to close off their land to public use but are not able to enforce such a closure without considerable expense. There is no agency or organization responsible for maintaining these areas or supervising their use. As a result, litter is a major problem, as is the abuse of alcohol and drugs by some recreation users. Uncontrolled overnight camping and salmon poaching are also problems. These problems may become more pronounced as areas surrounding the creek become more urbanized and property owners attempt to develop them for other purposes. Planning now could help avoid these potential future problems.

In view of Clear Creek's existing significant recreational use and its potential for large-scale recreational development, Shasta County and the City of Redding should cooperate in planning for future recreational use and development around the creek. Acquisition of a public-use recreational easement along the creek and development of a trail system should be considered by the county and city as a future development alternative. The major source of funding for purchase and recreational development of this land could probably be obtained through the State Wildlife Conservation Board and through the Federal Land and Water Conservation Fund Program. Preliminary discussions indicate that local, State, and Federal agency representatives involved in review and approval of funding for this purpose view the proposal favorably.

CHAPTER IV. INSTREAM FLOW NEEDS

Clear Creek below Whiskeytown Dam has the potential for significant fisheries restoration because the flow throughout this reach is controlled by Whiskeytown Dam. The only exceptions are during periods of heavy tributary flows or when the reservoir spills water to the creek. The ability to control flows at Whiskeytown Dam makes it possible to maintain a flow release schedule that maximizes the quality and quantity of fishery habitat. This is a powerful management tool not available to most streams. The releases from Whiskeytown Dam and the estimated average tributary inflow between Whiskeytown and Saeltzer Dams are shown in Table 6.

TABLE 6

ESTIMATED AVERAGE ANNUAL FLOW AT SAELTZER DAM

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (ac-ft)
						(cfs)							
Release from Whiskeytown Dam	50	50	50	50	50	50	50	50	50	50	100	100	42,000
Ave. Normal Year Tributary Inflow	120	140	145	95	35	10	3	3	3	5	30	65	39,000
Total Flow at Saeltzer Dam	170	190	195	145	85	65	53	53	53	55	130	165	81,000

A major task of the Clear Creek fishery study was to determine the flow needs (relationship between flow levels and the amount of fishery habitat available) for three target species: chinook salmon, steelhead trout, and smallmouth bass. Salmon and steelhead were chosen with the objective of improving habitat conditions, while bass were selected to evaluate the possibilities of limiting their predation impacts on salmon and steelhead. The method used to make this determination is called the Instream Flow Incremental Methodology (IFIM) and was developed by the U. S. Fish and Wildlife Service cooperative Instream Flow Service Group at Ft. Collins, Colorado. This methodology is commonly regarded among fisheries biologists as the most advanced and accurate means of predicting changes in the amount and quality of fish habitat resulting from various levels of streamflow.

The IFIM technique uses computer modeling to simulate stream system variations in fishery habitat at different flow release levels. Basically, it creates a computer model of the stream, using data collected at three different flow levels. These data define such stream characteristics as water depth and velocity, stream bottom composition (substrate), and fish cover. Additional data defining the range of stream conditions at which chinook salmon, steelhead, and smallmouth bass are found throughout their various life phases (fish preference curves) are also supplied to the computer. The computer program then compares existing stream conditions at various flow levels with the range of conditions preferred by the target fish species at various life stages and calculates the amount of usable fishery habitat (called weighted usable habitat - WUH) available to these fish. The procedure is fairly complex and is continually being improved by the Instream Flow Group to more closely model actual stream conditions. A detailed description of the IFIM is contained in the U. S. Fish and Wildlife publications listed in the bibliography.

The instream flow study covers the entire 16.5 miles of Clear Creek below Whiskeytown Dam, although most of the data were collected below Saeltzer Dam. Data representing stream conditions were collected at five study-reach locations below Saeltzer Dam and one above. The location of these study reaches and the total creek areas they represent are shown in the atlas presented in Chapter II. Study reach descriptions and statistics are given in Tables 7 and 8. These reaches were selected by a team composed of DFG fishery biologists and DWR engineers.

Each study reach consists of 7 to 15 transects (lines across the creek along which data-collection points were established). Data on water depth and velocity, substrate composition, and fish cover were collected at each transect. The data were collected during flow releases from Whiskeytown Dam of 50, 150, and 300 cfs. Tributary inflow below Whiskeytown Dam was insignificant during the measurement periods.

The initial data collection period was from June 9 through July 10 of 1982. Enough data were collected to determine the instream flow needs at that time. However, in March of 1983, an extremely intense and prolonged storm resulted in flows ranging from 12,000 to 18,000 cfs for several days in lower Clear Creek. This was the highest flow since the Igo stream-gaging station was established in 1940. This storm greatly changed the character of the creek in several areas below Saeltzer Dam, as illustrated in the photographs on pages 48 and 49.

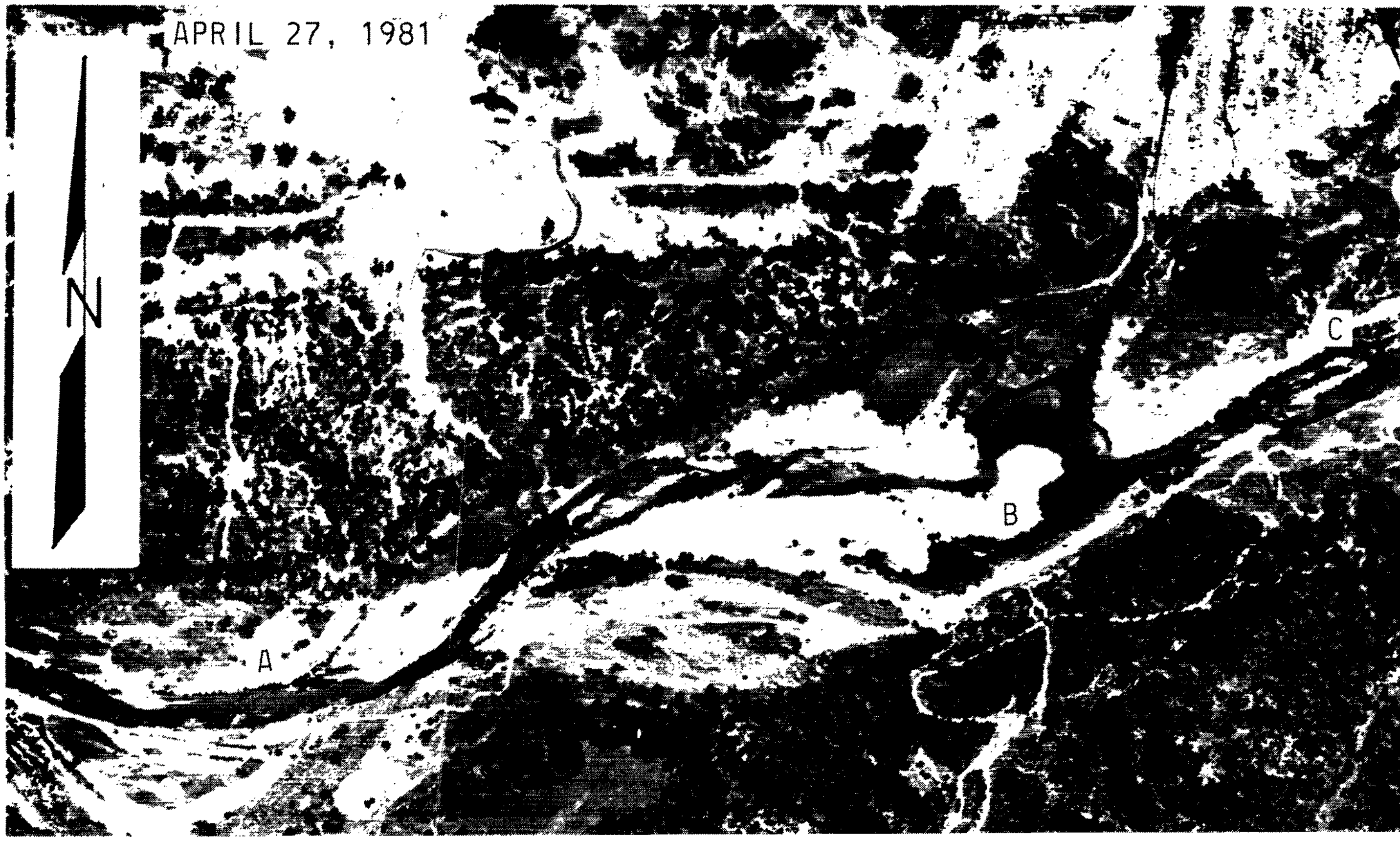
Generally, the creek changed channel locations along a 1.5-mile reach and the channel was widened in other areas. Excellent riffle areas on the Renshaw property (near mile 4.7) and below the Highway 273 bridge (mile 0.7) were washed out, leaving areas now classified as run and pool habitat in their place.

As a result of these large-scale changes, some of the data collected in 1982 were no longer valid. Therefore, from June 28 through July 13 of 1983, additional data were collected at three new study reaches (G and H), and two of the 1982 study reaches were eliminated (C and D). Addition of the three new study reaches in 1983 is responsible for the unsequential labeling of study reaches shown in the atlas. One of the reaches that was greatly changed by floodflows was still used in the model, since the original data closely represented an upstream reach that was unchanged by the flood.

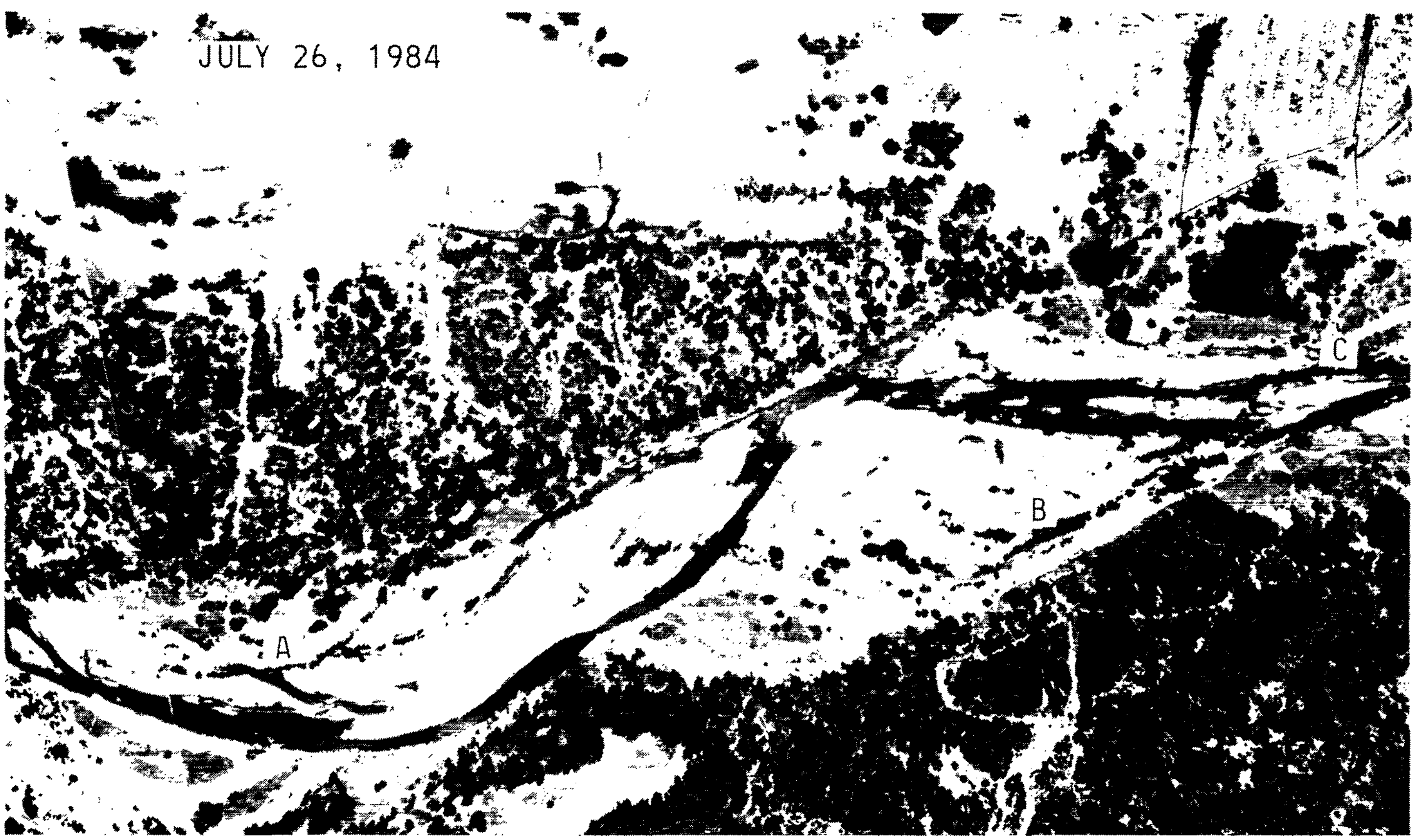
TABLE 7

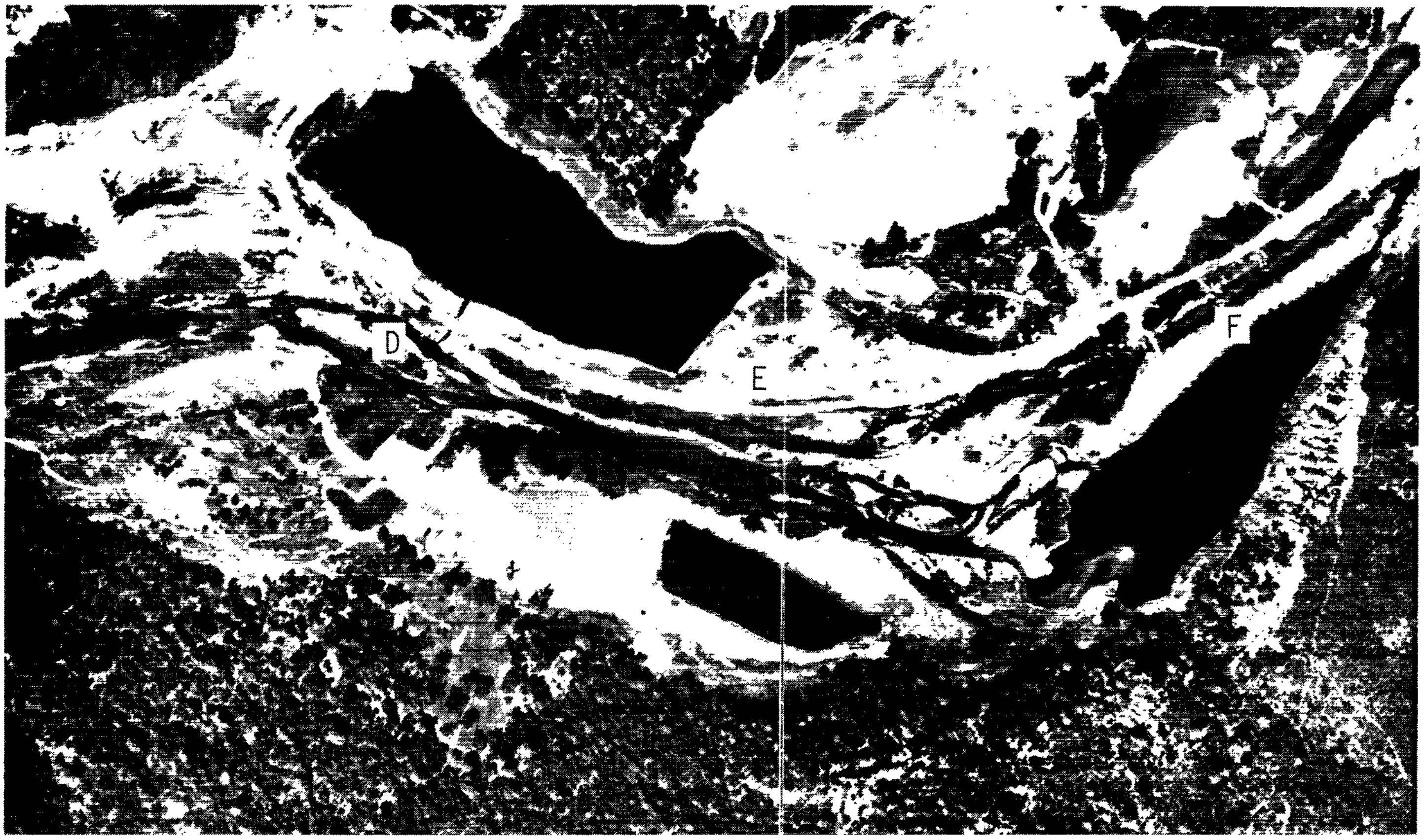
STUDY REACH DESCRIPTIVE SUMMARY

Study Reach	Description
A	This reach consists of a wide pool/wide riffle sequence in the downstream half and several braided narrow pool/narrow riffle sequences in the upstream half. Overhead cover was 5 percent in the lower half. The upper half had no cover. The upper section's narrow channel had a water plant growth covering half the channel. Spawning gravels were plentiful and of good quality. This area was changed to pool-and-run habitat during the 1983 high water. The data collected at this reach still apply to the creek immediately above the Highway 273 bridge.
B	This reach consists of a wide-shallow pool/narrow-deep pool/ narrow riffle/narrow-shallow pool sequence. Overhead cover is 30%. Riffle spawning gravels are good. This area wasn't changed significantly during 1983 high water.
C & D	These study reaches and the areas they represented were greatly changed during 1983 high water; therefore, data collected were not used and new study reaches F and G were established after the floods to represent this area.
E	This reach, located in the steep canyon area above Saeltzer Dam, consists of a wide-shallow pool/wide-deep pool/narrow riffle/wide-shallow pool/wide riffle sequence. Overhead cover is 15%. Riffle spawning gravels are poor (large gravel to large cobble). Large amounts of decomposed granite (DG) exist in pools. Channel slope is greater than at lower reaches. This one reach represents all the canyon habitat (8 miles) above Saeltzer Dam.
F	Study reach F consists of a wide-shallow pool/wide-deep pool sequence with 15% overhead cover. The bottom is composed of DG-covered cobbles. Most pool habitat below Saeltzer Dam is represented by this reach.
G	Study reach G consists of a narrow riffle/wide-deep pool sequence with no overhead cover. Good spawning gravels exist in this riffle.
H	This reach consists of a split channel of narrow pools/narrow riffles in the downstream half and a single channel with a wide riffle/wide pool sequence. The single channel area has good gravel, but the split channel contains pockets of gravel in a clay bed formation. The whole reach has about 5% overhead cover.



Comparison of the Clear Creek channel, between miles 2.4 and 4.0, before and after the





Approx. scale 1" = 500'

March 1983 flood. This is the area of greatest change in channel alignment and character.

TABLE 8

STUDY REACH STATISTICS

Study Reach	Reach Stream Mile	Length (feet)	Number of Transects	Creek Length Represented (1,000 feet) Mouth to Saeltzer	Mouth to Whiskeytown
A	0.5	900	15	2.75	6.28
B	2.2	980	13	7.15	10.69
C	4.1	860	10	*	*
D	4.8	1,100	10	*	*
E	9.8	570	10	0	45.14
F	4.9	670	4	12.46	12.46
G	2.8	470	7	3.89	7.43
H	3.3	840	9	6.04	6.04

* Study reaches C and D were not used due to changes caused by high water in March 1983.

The computer-generated data output of the instream flow needs study, along with the fish preference curve data, is published in a separate appendix report (DWR, 1985). This report is available but will probably be useful only to those familiar with the IFIM. The output data are summarized in Tables 9 and 10. Table 9 gives the percentage of optimum spawning habitat for chinook salmon (S), steelhead (SH), and bass (B) at each study reach location for creek flows from 40 to 500 cfs. Table 10 shows the same data for the composite stream reaches from the mouth to Saeltzer Dam, the mouth to Whiskeytown Dam, and the Clear Creek road bridge to Whiskeytown Dam. Similar information for rearing habitat at three life stages (adult, juvenile, and fry) is shown in Tables 11 and 12. The weighted usable habitat at the optimum flow is included in each table. "Perfect Substrate" is used to demonstrate the potential for improvement if ideal substrate conditions can be realized.

Table 13 shows the percent of optimum fishery habitat occurring at four flow-release schedules varying from the existing release to optimum.

TABLE 9

OPTIMUM SPAWNING HABITAT CORRESPONDING WITH VARIOUS FLOWS
AT REPRESENTATIVE STUDY SITES ON CLEAR CREEK

FLOW (CFS)	SITE A			SITE B			SITE G			SITE H			SITE F			SITE E		
	S	SH	B	S	SH	B	S	SH	B	S	SH	B	S	SH	B	S	SH	B
								(Percent of Optimum Habitat)										
40	91	71		77	41		39	35	86	24	13	26	3	0	76	96	84	72
50	97	80	95	86	52	80	46	44	88	31	18	38	7	0	80	98	91	74
62	>100	90		94	63		53	52	90	39	24	52	12	4	83	>100	99	77
75	98	95	>100	98	72	94	61	57	91	47	31	62	18	10	89	95	99	80
87	94	98		99	79		67	61	93	55	35	70	25	16	91	89	>100	83
100	89	>100	94	>100	86	99	72	67	94	62	41	79	32	21	95	86	99	85
112	84	99		99	90	>100	75	76	95	68	46	84	36	27	96	84	94	87
125	79	98	87	99	94	99	78	81	96	74	52	90	42	33	99	81	90	90
137	75	95		97	97	99	81	83	97	78	57	93	46	37	99	76	88	93
150	71	93	81	94	98	98	85	86	98	82	64	96	52	42	>100	72	88	95
175	63	88		90	>100		92	90	99	89	75	99	61	51	99	65	86	98
200	55	81	73	86	99	85	97	94	99	95	84	>100	72	59	99	62	83	98
228	49	73		82	97		>100	96	>100	98	90	99	84	76	98	59	78	98
280	44	67	69	79	94	76	99	97	99	>100	96	98	99	86	97	57	76	>100
300	37	57	68	71	88	70	96	99	99	98	>100	90	>100	>100	88	49	75	99
400	29	44		53	70	70	90	99	97	86	96	81	75	93	76	41	75	99
500	26	39		42	56		87	>100	96	76	85	84	63	88	78	37	74	
								Weighted Usable Spawning Habitat at Optimum Flow (1000 Sq.Ft. of Habitat per 1000 Ft. of Stream Reach)										
Existing Substrate	12	11	12	17	22	20	24	18	34	80	77	20	5	9	16	1	1	4
Perfect Substrate	19	22	18	23	33	22	39	46	42	97	96	25	30	58	49	23	32	19
								Portion of Reach Represented by Site										
Mouth to Saeltzer Dam		-9%-			-22%-			-12%-			-19%-			-38%-			-0%-	
Mouth to Whiskeytown Dam		-7%-			-12%-			-9%-			-7%-			-14%-			-51%-	

> = Optimum Flow   S = Chinook Salmon   SH = Steelhead   B = Smallmouth Bass

TABLE 10

OPTIMUM SPAWNING HABITAT CORRESPONDING WITH VARIOUS FLOWS
IN DESIGNATED REACHES ON CLEAR CREEK

Flow (cfs)	Mouth to Saeltzer Dam (6 mi)			Mouth to Whiskeytown Dam (16.5 mi)			Clear Creek Road Bridge to Whiskeytown Dam (7.9 mi)		
	S	SH	B	S	SH	B	S	SH	B
				(Percent of Optimum Habitat)					
40	37	21	70	49	29	76	96	84	72
50	45	27	77	56	36	81	98	91	74
62	52	35	83	64	45	87	>100	99	77
75	60	42	88	71	51	91	95	99	80
87	66	47	92	76	56	94	89	>100	83
100	72	53	95	80	62	97	86	99	85
112	76	59	97	84	67	98	84	94	87
125	80	64	99	87	72	>100	81	90	90
137	84	70	99	89	75	99	76	88	93
150	87	73	>100	91	80	99	72	88	95
175	91	81	99	94	86	99	65	86	98
200	96	87	97	98	91	99	62	83	98
225	98	93	96	99	95	98	59	78	98
250	>100	97	94	>100	98	97	57	76	>100
300	97	>100	88	96	>100	93	49	75	99
400	83	92	82	82	91	89	41	75	99
500	73	83		73	83		37	74	
				Weighted Usable Spawning Habitat at Optimum Flow (1000 Sq.Ft. of Habitat per 1000 Ft. of Stream Reach)					
Existing Substrate	746	806	617	931	995	1014	61	45	181
Perfect Substrate	1303	1705	1121	2478	3455	2243	1032	1443	839

> = Optimum Flow S = Chinook Salmon SH = Steelhead B = Smallmouth Bass

TABLE 11

OPTIMUM REARING HABITAT CORRESPONDING WITH VARIOUS FLOWS
AT REPRESENTATIVE STUDY SITES ON CLEAR CREEK

FLOW (CFS)	SITE A			SITE B			SITE G			SITE H			SITE F			SITE E		
	S Juv.	SH Juv.	B Fry	S Juv.	SH Juv.	B Fry	S Juv.	SH Juv.	B Fry	S Juv.	SH Juv.	B Fry	S Juv.	SH Juv.	B Fry	S Juv.	SH Juv.	B Fry
	(Percent of Optimum Habitat)																	
40	73	96	96	84	87	>100	76	75	84	73	68	80	84	81	>100	81	82	95
50	75	98	93	87	90	99	80	78	85	81	74	87	89	84	99	86	88	98
62	76	99	90	88	93	92	86	83	90	87	80	93	93	86	97	90	92	99
75	76	>100	86	90	95	97	90	87	93	92	84	98	96	89	96	93	96	>100
87	76	99	83	92	96	96	94	90	95	95	88	>100	98	91	96	96	98	99
100	75	99	79	94	97	95	96	93	97	96	89	98	99	93	95	98	99	97
112	74	99	76	95	98	95	98	95	98	97	92	97	>100	94	93	99	>100	95
125	73	97	74	96	99	95	99	96	99	98	94	96	99	95	92	>100	99	92
137	72	96	73	97	99	95	99	97	>100	98	95	95	99	97	91	99	99	89
150	72	95	72	98	99	96	>100	98	99	99	97	94	99	97	90	99	99	87
175	71	92	71	>100	99	96	99	99	99	99	98	91	98	99	88	96	98	82
200	71	89	70	99	>100	94	99	99	98	98	99	88	96	>100	86	92	96	77
228	71	88	71	98	99	93	98	99	96	97	99	85	94	99	84	89	94	73
280	72	88	74	96	98	90	97	>100	95	>100	>100	86	92	99	81	86	92	71
300	78	89	84	92	95	86	95	99	91	97	96	78	88	98	77	81	88	67
400	90	94	99	87	88	79	91	95	86	89	85	63	79	88	64	74	80	64
500	>100	92	>100	87	81	76	89	91	85	77	79	54	72	79	56	69	75	63
	Weighted Usable Rearing Habitat at Optimum Flow (1000 Sq.Ft. of Habitat per 1000 Ft. of Stream Reach)																	
Existing Substrate	42	37	33	44	52	39	73	88	57	77	121	110	64	75	40	46	49	37
	Portion of Reach Represented by Site																	
Mouth to Saeltzer Dam	-9%-			-22%-			-12%-			-19%-			-38%-			-0%-		
Mouth to Whiskeytown Dam	-7%-			-12%-			-9%-			-7%-			-14%-			-51%-		

> = Optimum Flow S = Chinook Salmon SH = Steelhead B = Smallmouth Bass

TABLE 12

OPTIMUM REARING HABITAT CORRESPONDING WITH VARIOUS FLOWS
IN DESIGNATED REACHES ON CLEAR CREEK

	Mouth to Saeltzer Dam				Mouth to Whiskeytown Dam				Clear Creek Road Bridge to Whiskeytown Dam			
Flow (CFS)	S Juv.	SH Adult	SH Juv.	SH Fry	S Juv.	SH Adult	SH Juv.	SH Fry	S Juv.	SH Adult	SH Juv.	SH Fry
	(Percent of Optimum Habitat)											
40	82	29	78	93	82	31	81	95	81	29	82	95
50	87	34	82	96	87	36	86	98	86	34	88	98
62	91	40	86	98	91	41	90	99	90	39	92	99
75	94	45	89	99	94	48	94	99	93	46	96	>100
87	97	51	92	>100	96	54	96	>100	96	53	98	99
100	98	57	93	99	98	61	97	98	98	61	99	97
112	99	63	95	98	99	67	98	97	99	70	>100	95
125	99	68	96	97	99	73	99	95	>100	74	99	92
137	99	72	97	97	>100	78	99	94	99	80	99	89
150	>100	76	98	96	99	82	99	93	99	85	99	87
175	99	85	99	94	98	89	>100	89	96	92	98	82
200	98	92	99	92	96	95	99	86	92	98	96	77
225	97	97	99	90	94	98	98	83	89	99	94	73
250	96	>100	>100	89	92	>100	98	82	86	>100	92	71
300	94	99	97	84	88	99	94	78	81	98	88	67
400	87	95	89	73	82	90	87	72	74	84	80	64
500	82	90	83	66	78	84	81	68	69	78	75	63
	Weighted Usable Rearing Habitat at Optimum Flow (1000 Sq.Ft. of Habitat per 1000 Ft. of Stream Reach)											
Existing Substrate	1921	1202	2460	1701	4526	3090	5245	3761	2089	1612	2219	1650

> = Optimum Flow S = Chinook Salmon SH = Steelhead

TABLE 13

PERCENT OF OPTIMUM FISHERY HABITAT BY MONTH RESULTING FROM ALTERNATIVE STREAMFLOW REGIMES (IN CFS) OCCURING FROM SAELTZER DAM TO THE MOUTH DURING YEARS OF NORMAL STREAMFLOW

(The additional quantity of water required to make the alternative fishery releases is shown on the last line.)

	NEAR OPTIMUM FLOW _1/				80% OF OPTIMUM FLOW				65% OF OPTIMUM FLOW				EXISTING FLOWS			
MONTH	Salmon		Steelhead		Salmon		Steelhead		Salmon		Steelhead		Salmon		Steelhead	
	CFS		CFS		CFS		CFS		CFS		CFS		CFS		CFS	
January	250	_2/	250		200		200		170	90%	170	79%	170	90%	170	
February	250		250		200	96%	200	87%	190		190		190		190	
March	250		250		200		200		195	93%	195	85%	195	95%	195	
		100%		97%		98%										
April	225		225		180		180	96%	150		150	76%	145	86%	145	
May 1	150		150		120		120		100	89%	100		85		85	
May 15	150		250		120	100%	200		100		160		85	95%	85	
		*				*				*				*		
June	50	* _3/	250		50	*	200		50	*	160		60	*	60	
July	50	*	250		50	*	200	80%	50	*	160	65%	50	*	50	0% _4/
August	50	*	250	100%	50	*	200		50	*	160		50	*	50	
		*				*				*				*		
September	50	*	250		50	*	200		50	*	160		50	*	50	
October 1	50	*	250		50	*	200		50	*	160		55	*	55	
October 15	250		250		200		200		160		160		55	47%	55	
		100%		97%		96%		87%		89%		76%				
November	250		250		200		200		160		160		130	82%	130	
December	250		250		200		200		160		160		165	89%	165	
Total Quantity of Additional Water Required _5/ (Acre-Feet)	42,500		99,200		21,100		63,500		6,500		3,800		0			

_1/ Flows shown in the table are composed of Whiskeytown Dam releases plus tributary inflows below the dam.

_2/ The percent columns reflect the optimum fishery habitat occurring at the flow release shown in the left adjacent column.

_3/ Asterisks indicate periods when salmon are not present in the stream.

_4/ Zero percent steelhead habitat due to lethal summer water temperature.

_5/ Flow releases shown are for normal years which occur approximately 79 percent of the time. During dry years (12 percent of the time), flows would be reduced to 65 percent of normal and during critically dry years to 40 percent of normal. Flow releases under no conditions would be reduced below the currently existing schedule.

NOTES:

A. Additional fishery attraction flow releases during the October-November period will be made in the magnitude of 5,000 acre-feet during normal years.

B. The optimum summer steelhead flow is shown at 250 cfs instead of 300 cfs to obtain more steelhead juvenile and fry habitat while not increasing water temperature significantly.

Development of Instream Flow Recommendations

Selecting a recommended flow-release schedule based on IFIM is not an exact science, but relies partly on subjective judgment and the willingness of those involved in the process to compromise. In an attempt to develop a joint recommended flow schedule, two meetings were held with representatives of the Departments of Water Resources and Fish and Game, the U. S. Bureau of Reclamation, and the U. S. Fish and Wildlife Service. An agreement on the general magnitude of optimum flow levels for both salmon and steelhead shown in Figure 5 resulted from these meetings. Other general areas of agreement concerning the determination of instream flow releases are listed as follows.

1. In analyzing the impacts of supplying additional water for instream flows, deficiencies of 40 percent for dry years and 60 percent for critically dry years should be applied to the recommended fishery releases. However, releases at Whiskeytown Dam should never be less than the current minimum release of 100 cfs during November and December or 50 cfs during the remainder of the year.

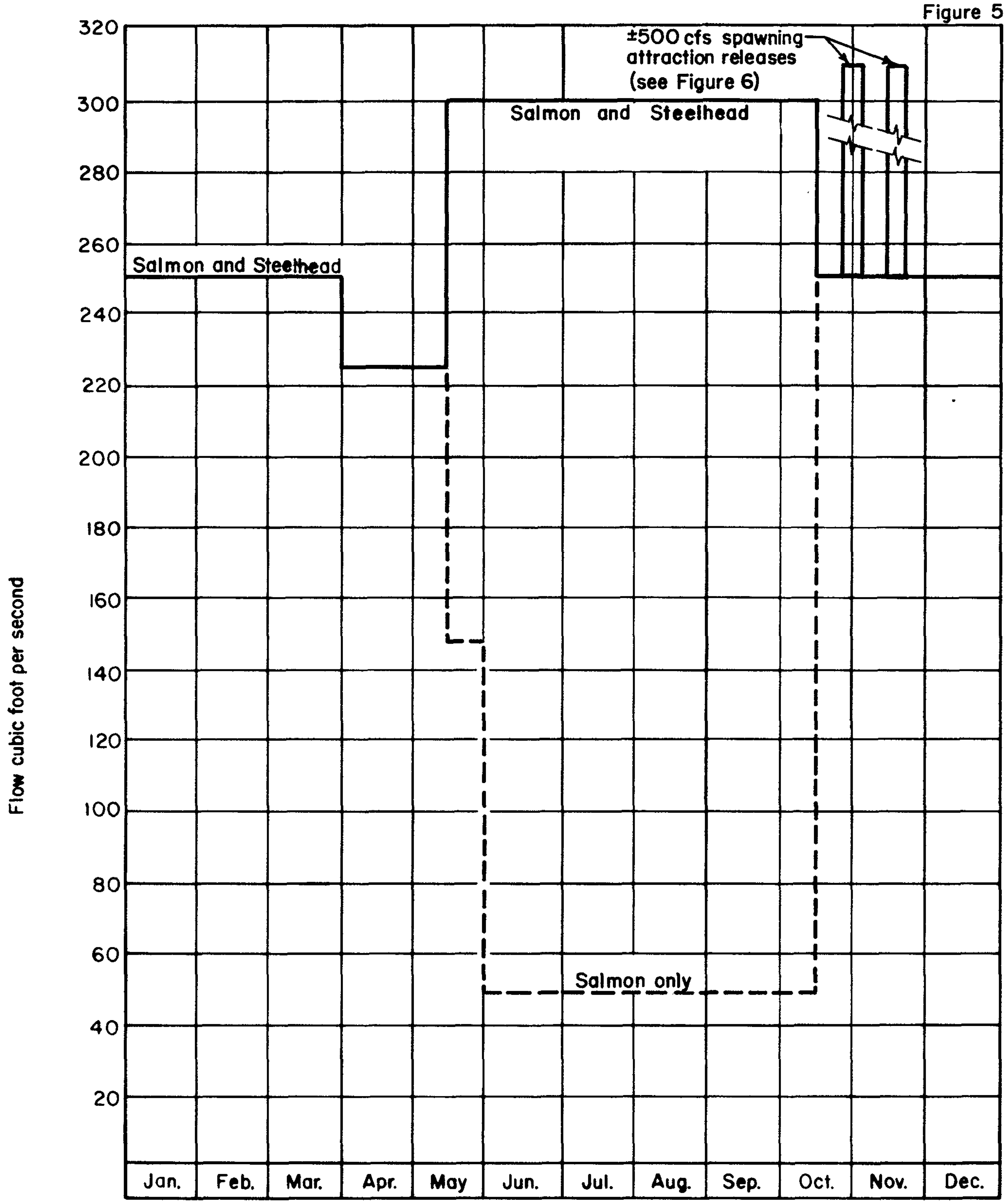
2. Tributary streamflows occurring below Whiskeytown Dam should be included in computing the additional releases required from Whiskeytown Dam to meet the total recommended fishery flow needs.

3. Spawning habitat appears to be the limiting factor for salmon production, while summer-rearing habitat resulting from high water temperatures is the limiting factor for steelhead. Rearing habitat for steelhead can be greatly increased by increasing summer flows to provide cooler water temperatures.

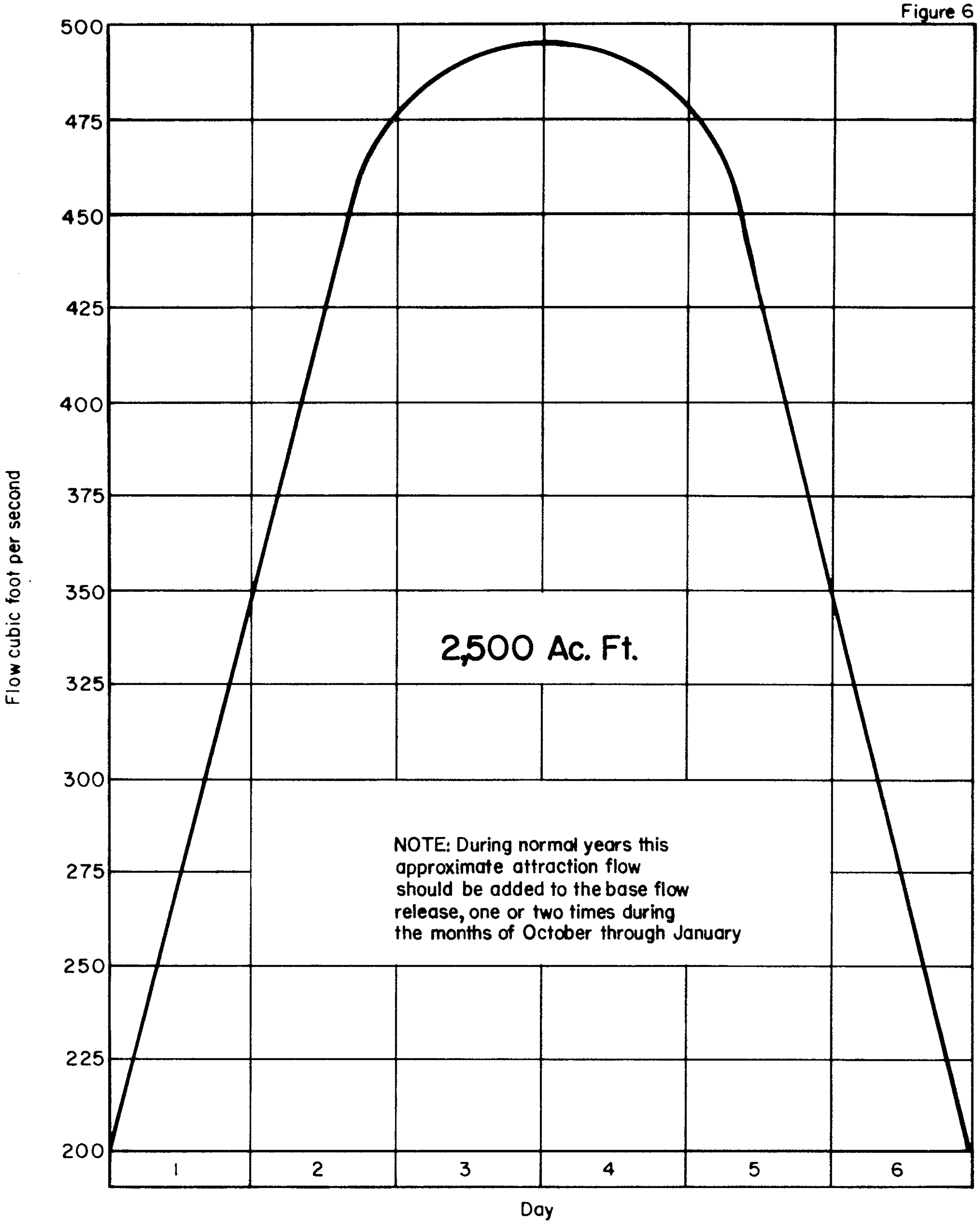
4. Attraction flows of up to $\pm$ 500 cfs, as shown on Figure 6, should be released for short periods from one to four times a year from October through January as needed to attract adult salmon and steelhead into Clear Creek. Past observation indicates that salmon have used the creek most heavily for spawning during years of high early flows.

As a result of data analysis, numerous agency meetings, and discussions concerning the most desirable flow-release schedule, the generalized schedule shown in Figure 7 and Table 14 was developed by DWR. This schedule is intended as a first proposal for consideration by all interested agencies and individuals. It could be used as an interim flow release schedule for monitoring purposes and would be "fine-tuned" as its fishery impacts are determined. If implemented, the proposed schedule would approximately double the quantity of water presently released from Whiskeytown Reservoir into Clear Creek (from 42,000 to 91,000 acre-feet per year), and would result in substantial improvement in the creek's salmon and steelhead habitat from Whiskeytown Dam to the mouth.

Figure 5



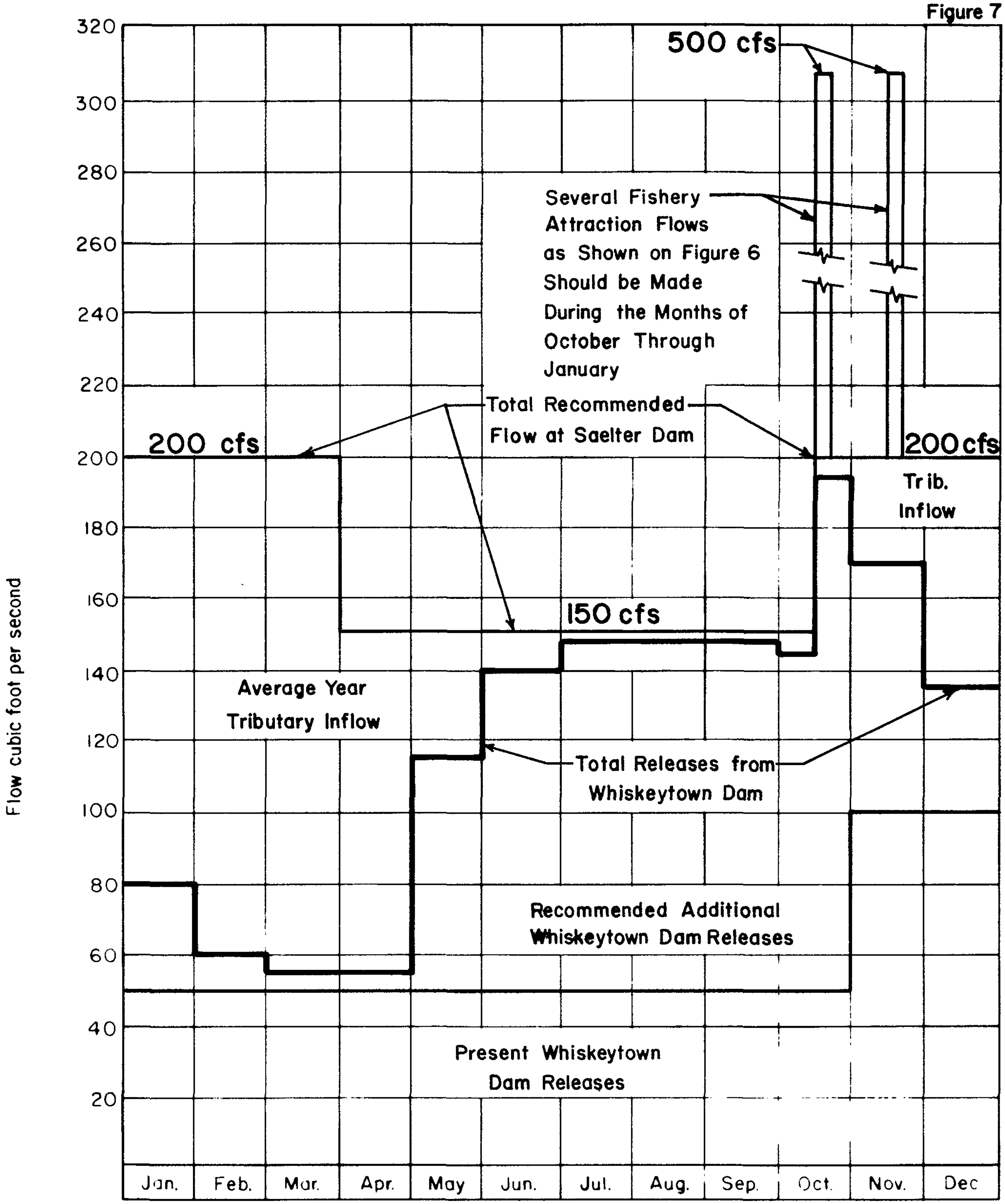
Comparative Flow Release Schedule for Optimum Salmon and Steelhead Habitat



Recommended Spawning Attraction Flow Release Schedule

C-064862

Figure 7



Recommended General Flow Schedule for Maintenance of Salmon and Steelhead

TABLE 14

COMPONENTS OF THE GENERALIZED RECOMMENDED FLOW RELEASE SCHEDULE
(in cubic feet per second)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct 1-15	Oct 16-31	Nov	Dec	Total (ac-ft)
Present Releases from Whiskeytown Dam	50	50	50	50	50	50	50	50	50	50	50	100	100	42,000
Recommended Additional Releases	30	10	5	5	65	90	97	97	97	95	145	70	35	49,000 1/
Ave. Normal Year Tributary Inflow	120	140	145	95	35	10	3	3	3	5	5	30	65	39,000
Recommended Total Flow at Saeltzer Dam	200	200	200	150	150	150	150	150	150	150	200	200	200	130,000

1/ Total includes two 2,500 acre-foot spawning attraction releases sometime during October and November.

The U. S. Bureau of Reclamation is responsible for operation of Whiskeytown Reservoir and will be the agency that ultimately must decide on the level of flow releases into Clear Creek. The Bureau is now conducting a Central Valley fish and wildlife management study with help from various State and Federal resource agencies, including DWR, DFG, and the U. S. Fish and Wildlife Service. A special interagency team is assigned to work on a Clear Creek anadromous fishery improvement study. Results of this study are scheduled for publication in the fall of 1986.

Impacts of Releasing Recommended Flows

The recommended initial flow release schedule would approximately double the amount of water released into Clear Creek from Whiskeytown Reservoir. These releases would have a significant beneficial impact upon the creek's fishery habitat. They would increase the quantity of spawning and rearing habitat in the lower 8 miles by about 10 percent under present conditions. This action by itself will produce only a moderate increase in habitat area, but when combined with other actions such as riffle ripping and reconstruction, sediment control, and fish passage at Saeltzer Dam, the resulting increase will be in the magnitude of several times existing habitat. An analysis of the overall increase in fish use resulting from various combinations of actions proposed in this report is being prepared by the U. S. Fish and Wildlife Service for the Bureau of Reclamation's Central Valley Fish and Wildlife Management Study. Results of this study should be available in the fall of 1986.

Increased instream flows would extend the amount of time the creek flows are high enough for spawning. Many salmon are ready to spawn in early October, but available riffles are often unsuitable because of low flows in tributary streams. The recommended flow schedule would provide fall attraction flows to bring more fish into the creek during the early part of the run. Thereafter, adequate flows would be maintained for spawning use.

Summer flows should be maintained at approximately 150 cfs to provide suitable water temperatures (below 75 degrees F maximum) for steelhead rearing. This would allow year-round use by steelhead, which are presently excluded by unsuitably high summer water temperatures. Lowering of these temperatures will probably have some negative impact on creek swimming use above mile 4, but this could be partially offset by increased tubing and rafting use made possible by the higher summer flows. Below mile 4, summer water temperatures should normally remain in a range acceptable for swimming (65 to 75 degrees F).

Increased reservoir releases would also have a steadying effect on the creek by reducing the relative impact of highly fluctuating natural tributary inflows. Additional reservoir releases would be most beneficial during prolonged drier periods or between storms when natural inflow becomes low. Fishery benefits would also result from reducing reservoir releases during periods of higher than optimum tributary inflows, although minimum releases at Whiskeytown Dam should never drop below 50 cfs.

To maximize fishery benefits while keeping releases from Whiskeytown Reservoir at a minimum, reservoir releases should be closely coordinated with available natural flows. The ideal operating procedure would be daily adjustment of flow releases based on the level of tributary inflow measured at the Igo stream gage. (Automation of the water release control valves at Whiskeytown Dam may be required to accomplish this.) Because of the moderate length of creek affected (below Whiskeytown Dam) and the generally concentrated character of tributary streams (most tributary flow occurs above mile 10), fine tuning of the reservoir release schedule on a daily basis during periods of rapidly fluctuating tributary inflow could be very effective to maintain near optimum flows in the best habitat reach (the lower 10 miles) of Clear Creek.

Since any additional water released below the dam will result in reduced power generation from Spring Creek and Keswick Powerhouses, there is an energy loss associated with increased flows in Clear Creek. Once the City of Redding completes construction of its hydropower project on Whiskeytown Dam, water released from the reservoir to Clear Creek will recover part of this loss. Assuming approximately 50,000 acre-feet of additional annual releases down Clear Creek an annual reduction of about 17.5 million KwH would result.

During years defined as dry and critically dry, the augmented flow releases to Clear Creek could be reduced to help prevent power shortages. A possible reduction schedule could be a 40 percent deficiency during dry years and 60 percent during critically dry years. These percentage reductions are patterned after the recent Trinity River instream flow decision.

Releases of additional water into Clear Creek should not affect water levels at Whiskeytown Reservoir, since additional water released down Clear Creek would otherwise be diverted through the Spring Creek Tunnel to the Sacramento River. Flows in the Sacramento River downstream from the mouth of Clear Creek would remain essentially unchanged. However, a small reduction of up to 100 cfs in river flows between Keswick Reservoir and Clear Creek would occur during summer months.

Flow measurements at many transects were made to gather data for the instream flow study.

CHAPTER V. REHABILITATION OF CLEAR CREEK FISHERY HABITAT

Much of the damaged fishery habitat in Clear Creek could be rehabilitated by the following measures:

1. Additional instream flow releases to improve both the quantity and quality of habitat.

2. Riffle ripping to loosen and clean streambed gravels compacted with sand sediment.

3. Reconstruction of historic spawning riffle areas that have been degraded by floodflows and sediment deposits.

4. Control of sand-size sediment by construction and periodic excavation of sediment collection pools.

5. Construction of instream structures for habitat improvement and maintenance of the stream channel.

6. Purchase of land for habitat protection.

The additional flow releases were discussed in detail in Chapter IV. This chapter describes other rehabilitation techniques in more detail and evaluates their potential application to Clear Creek.

Riffle Ripping

This is a rather simple and inexpensive technique for improving spawning and rearing habitat. It involves use of a bulldozer with ripping attachment to loosen the compacted stream bottom and expose it to water velocity. This washes some of the sediment downstream and out of the immediate riffle area. To be effective it must be repeated periodically, depending on how much sand and sediment is produced upstream. Ripping is performed in riffle areas that have been degraded by sediment deposition and become too compacted for spawning fish to easily dig nests in. If fish do manage to spawn in such areas, their eggs often do not receive adequate oxygen due to low streambed permeability, or the hatched "fry" are trapped by the sand.

Part of this removed sand will be flushed out of the stream during high winter flows, but part of it will eventually deposit on downstream riffle areas. Ripping should therefore be performed from an upstream to downstream direction. Ripping can also be combined with pool construction to trap and remove the loosened sand. The cost of ripping is approximately $50 per 1,000 square feet. It would cost approximately $20,000 to rip all the suitable riffle areas in Clear Creek below Saeltzer Dam, assuming required access could be obtained. After ripping, some monitoring work should be conducted to evaluate the effect on the habitat and to determine when additional ripping work needs to be done.

Reconstruction of Spawning Riffles

Several productive riffle areas on Clear Creek were degraded or destroyed by the March 1983 high water. Most severely damaged were the Renshaw riffle and the 1/4 mile reach below the Highway 273 bridge. Both of these extensive areas were completely changed from riffle to run-and-pool habitat. Before the flood damage, the Renshaw riffle was the best single spawning area on the creek. It contained the highest concentration of spawning fish counted in 1981 and 1982. Although the flooding did create some new spawning riffles downstream, they are not equivalent in size to the areas lost.

Once productive, but now degraded, creek-spawning reaches can be rebuilt, as was done at numerous locations on the upper Trinity River near Lewiston. Clear Creek is an ideal area for riffle reconstruction because of the controlled flows below Whiskeytown Dam and the nearness of extensive commercial gravel resources.

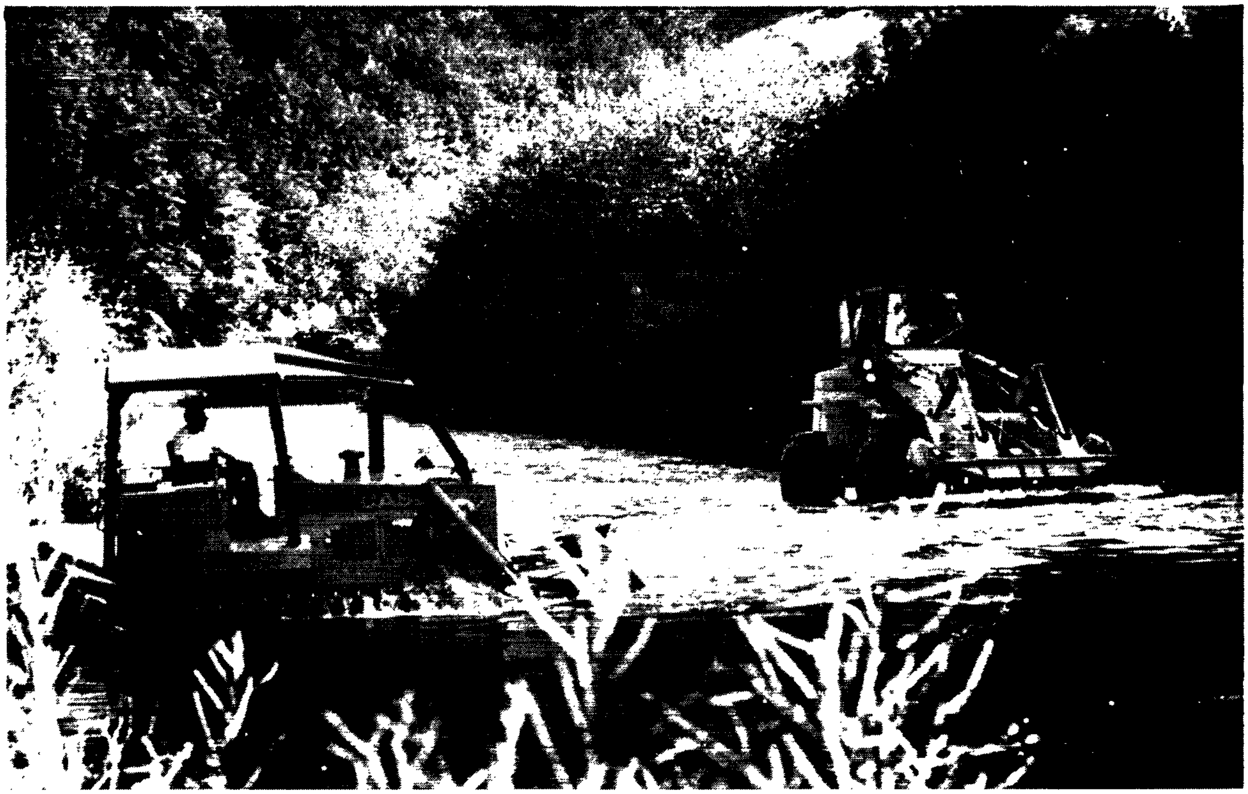
A significant factor in determining the cost of reconstructing riffle areas is the nearness and availability of suitable screened "fish rock" or spawning gravels between 1/2 inch and 4 inches in size. Commercial spawning gravels from outside the Clear Creek flood plain area are readily available within a 2.5-mile haul distance from all potential riffle restoration areas below Saeltzer Dam.

Riffle restoration requires a moderate amount of planning, design, environmental documentation, and acquisition of needed permits prior to the beginning of construction activities. The construction phase consists of hauling properly screened gravels to the riffle area and spreading them to a specified thickness and elevation. The estimated cost of this work for an average size riffle of 300 feet by 50 feet is approximately $1.10 per square foot, as shown below:

Riffle Reconstruction Cost Estimate

Mobilization and equipment	$ 5,200
Control structures	700
Spawning gravel	7,700
Subtotal	$13,600
Engineering and contingencies	2,700
Total	$16,300
Unit cost per ft^2 of spawning area	$ 1.10

About $100,000 would be required to reconstruct both the Renshaw and the riffles below Highway 273. An additional $150,000 would be needed to perform the other potentially needed riffle restoration work on Clear Creek. After reconstruction, these riffles will need some continuing periodic maintenance depending on the level, frequency, and duration of floodflows and the quantity of sand sediment carried by the creek. Long-term maintenance costs should average around $10,000 per year, but actual maintenance work would only be required every 3 to 5 years.



Riffle ripping (above) and placement of new spawning gravel (below) would increase fish-food production and nursery habitat and restore spawning areas.

Sediment Control

Approximately half of the Clear Creek watershed below Whiskeytown Dam is composed of granitic soils. These soils are part of the Shasta Bally Batholith formation, which is also the source of massive sediment problem in the Trinity River Basin. This study did not investigate specific sediment sources within the Clear Creek drainage, but it is known from sampling stream bottom materials that sand-size sediment is a significant problem that must be dealt with in order to greatly improve the creek's fishery habitat.

Sediment problems on the Trinty River have been controlled to a degree by constructing sediment trap pools and evacuating them as they fill. This method could also be applied to Clear Creek. The most obvious sediment control site on Clear Creek is at Saeltzer Reservoir, which is presently filled with sediment. Saeltzer Reservoir is located below all the tributaries that contribute sand to the creek, and therefore it could trap nearly all of this material before it reached the better spawning gravels in the lower 6 miles. The reservoir also has good access to a county road for efficient transport of excavated materials to disposal sites. Pool construction at this site would also increase the reservoir's recreation potential.

The pool would be constructed by a large dragline or backhoe (hydraulic excavator) loading into dump trucks. The spoil material would be hauled to disposal areas above the flood plain and could be beneficially used to surface nearby dredger tailing areas for possible reclamation. Average depth of the pool would range from 10 to 15 feet below water surface and the maximum capacity would be approximately 30,000 cubic yards. Cost of initial excavation and disposal of material would range from $6 to $10 per cubic yard, depending on hauling distances to disposal sites.

There may be other suitable sediment trap sites in the 2-mile reach between Saeltzer Dam and the Clear Creek road bridge, but it appears that Saeltzer Reservoir is probably the most favorable for initial construction. The steep canyon area upstream from the bridge appears unsuitable for pools because of shallow bedrock conditions and lack of easy access for equipment.

Stream Fishery Habitat Improvement Structures

A current trend in fishery habitat improvement is construction of stream channel structures to control water depth, direction and velocity to benefit the fishery. These structures are usually made of logs, timbers, boulder clusters, or gabions (rocks placed in wire baskets), and their design is tailored to correct specific stream conditions, such as lack of pools, spawning gravels, or cover. The types of structures most applicable to Clear Creek are rock clusters, gabions, and log weirs.

Boulders of 1 cubic yard or larger size are ideal for creating a diversity of habitat conditions in an otherwise uniform and unproductive reach of stream. Boulders can create cover by providing shade, turbulence, and scour pools. Boulders are normally placed in clusters of three to five. The cost of boulder placement ranges from $40 to $75 per cubic yard if a source of rock is nearby and if good stream access is available, as is the condition on Clear Creek. Population increases of more than 100 percent for steelhead "smolts" have been documented in the Smith River drainage as a result of boulder placement.

Low check dams or log weirs extending across the stream at various angles or configurations, such as V or Y, can be used to slow water velocity, create and maintain pools, catch and retain spawning gravel, and provide cover for young fish. These structures, although simple and relatively inexpensive to construct, require site-specific design based on a thorough analysis of existing stream configuration, hydrology, and habitat conditions. Low dams can be constructed of large rock clusters, gabions or logs. The current preference seems to be for log or loose rock weirs, mainly because of their more natural appearance and lower cost. However, gabions may be more applicable on Clear Creek because of the extensive availability of small rock.

Several stream reaches on lower Clear Creek have a hard clay bottom, devoid of gravel deposits. Such areas do not provide suitable habitat for salmon and steelhead during any phase of their life cycle. Construction of gabions or low rock or log dams at the lower end of these reaches would pond water and catch gravels to create usable spawning and rearing habitat.

Partly as a result of the 1983 flood, which filled pools and washed away much riparian vegetation, several reaches of Clear Creek do not have much hiding or escape habitat. Fish in these areas are very vulnerable to predation. In-stream structures can be constructed or placed to provide suitable fish cover and shelter at strategic locations, such as pools or undercut banks, where fish would likely congregate. Cover structures are normally made of poles or logs placed along streambanks either above or below the water surface. Design is quite flexible, depending on site specific stream conditions. The structure must be properly located and anchored to avoid creating erosion or flooding problems.

Planting of streamside vegetation provides another form of overhead cover. The proper type and amount of vegetation will not only improve cover conditions but will also help stabilize streambanks, cool the water, and increase the fish food supply as a result of insects dropping into the water from overhanging vegetation.

In areas where natural streambank erosion provides a source of suitable spawning gravels to the creek bottom, streambank vegetative growth should be discouraged. Consideration should be given to placement of instream structures that would increase streambank erosion in these areas. Such structures would direct the water velocity against the streambank during high flows. Another potential method of increasing available streambed gravels is to mechanically push suitable stream terrace gravels into the creek preceding high flows.

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Purchase of Property Easements for Habitat Protection

The lower 6 miles of Clear Creek below Saeltzer Dam are presently very valuable as anadromous fishery habitat. Also, the 2 miles of creek immediately above the dam have similar characteristics. This area would become accessible if planned fish passage work by DFG at the dam is successful. The most critical reach of creek is from mile 3.5 through 4.5, where the few remaining streamside gravel terraces are located. These terraces constitute the last remaining sizable source of fish spawning gravels below Saeltzer Dam that can migrate naturally into the stream channel during high flows. Their protection from mining is critical to the success of any fishery restoration program on the creek and they should receive priority attention.

The most certain way to protect these gravels is to purchase them. Another method is to purchase a conservation easement in instances where owners insist on excluding public use along the creek. DFG, in cooperation with the Wildlife Conservation Board, is investigating the possibility of purchasing portions of the flood plain along the lower reaches of Clear Creek. Property or easement purchase would make it possible to construct fishery restoration projects on the creek with the assurance that long-term maintenance work can also be performed.

CHAPTER VI. PLAN OF ACTION AND POSSIBLE FUNDING SOURCES FOR RESTORATION WORK

The preceding chapters identified several fishery restoration actions that could be implemented on Clear Creek. Most of those actions are patterned after work that has been conducted on the Trinity River since 1976. Many similarities exist between Clear Creek and Trinity River fishery problems. However, Clear Creek has only 16 miles of main stream available for restoration, compared with approximately 110 miles on the Trinity River.

Both DWR and the Bureau of Reclamation have ongoing fishery studies on Clear Creek. A statutory commitment in the 1955 Trinity River Division implementing legislation requires the Bureau of Reclamation to "insure the preservation and propagation of fish and wildlife" in both the Trinity River below Lewiston and Clear Creek below Whiskeytown Dam. Following is a list of suggested project priorities for work needed to "insure the preservation and propagation of fish and wildlife on Clear Creek."

1. The most significant single action that could presently be taken is modification of the instream flow releases below Whiskeytown Dam to a schedule generally similar to that shown in Figure 7.

2. Of equal priority is the preservation of streamside gravel terraces between mile 3.5 and 4.5, which will naturally provide most of the future spawning gravels in the heavily used lower portion of the creek. Limited long-term benefit would result from increased streamflows unless adequate quantities of spawning and rearing gravels are present. Purchase of the flood plain property or a resource conservation easement are probably the best methods of preserving these gravels.

3. A functional fish passage structure around Saeltzer Dam is a high-priority item that will open up several miles of additional fishery habitat. The Department of Fish and Game is planning to modify the existing ladder around the dam during the summer of 1986.

4. Several spawning riffles which have been damaged by erosion or sediment deposition should be reconstructed. The two most critical areas are the Renshaw riffle and the 1/4-mile reach downstream of the Highway 273 bridge.

5. All existing compacted riffle areas below Saeltzer Dam should be ripped to loosen and clean them. This work is relatively inexpensive and could probably be accomplished by a single dozer in 5 to 10 working days.

6. Accumulated sediment in Saeltzer Reservoir should be removed to provide a catchment pool for the detrimental decomposed granite sand before it is washed into the productive riffle areas below Saeltzer Dam.

7. The recent (November 1985) incidence of whirling disease in steelhead populations at the Coleman National Fish Hatchery on Battle Creek may greatly increase the desirability of improving steelhead habitat or of locating a hatchery on Clear Creek. This possibility should be evaluated fully in deciding how to maintain or improve steelhead populations in the upper Sacramento River Basin.

8. Additional site specific planning and design work should be performed to identify instream habitat improvement structure locations and types appropriate for construction on Clear Creek.

9. Additional study of artificial propagation possibilities (rearing ponds or hatchery) should be conducted by DFG, which is currently conducting some rearing and fish release experiments on the creek near the NEED Camp.

Several potential sources of funding could help support this work, but allocation of a portion of these funds to Clear Creek may depend to a large degree on the level of local government and conservation group support. Some specific sources of potential funding are:

1. The Renewable Resources Investment Fund was created by legislation passed in 1979. This fund provides a total of $10 million, a portion of which was designated for use in restoring salmon stocks. Over $1 million was allocated to this program during 1984-85.

2. Legislation passed in 1981 requires commercial salmon trollers to purchase an annual stamp costing between $55 and $215, depending on their previous year's catch. The stamp fees are administered by an advisory committee for the purpose of funding salmon restoration programs. Approxiamtely $600,000 was available in 1984-85.

3. The continuing California Environmental License Plate Fund Program contributed $1.4 million for construction of fish habitat restoration work, including spawning riffle construction in 1984-85.

4. Proposition 19, passed by the voters in June 1984, will provide a continuing source of funds for stream restoration for the next 5 years. In 1984-85, $1.25 million was allocated to this program.

5. Senate Bill 400 provides $5 million annually for 2 years to restore fisheries habitat.

6. In the future, funding could be provided by the State or Federal Government as mitigation for fisheries losses resulting from construction of new water projects in the Sacramento River Basin.

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CONVERSION FACTORS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit By	To Convert to Metric Unit Multiply Customary Unit By
Length	millimetres (mm)	inches (in)	0.03937	25.4
	centimetres (cm) for snow depth	inches (in)	0.3937	2.54
	metres (m)	feet (ft)	3.2808	0.3048
	kilometres (km)	miles (mi)	0.62139	1.6093
Area	square millimetres (mm^2)	square inches (in^2)	0.00155	645.16
	square metres (m^2)	square feet (ft^2)	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometres (km^2)	square miles (mi^2)	0.3861	2.590
Volume	litres (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons (10^6 gal)	0.26417	3.7854
	cubic metres (m^3)	cubic feet (ft^3)	35.315	0.028317
	cubic metres (m^3)	cubic yards (yd^3)	1.308	0.76455
	cubic dekametres (dam^3)	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic metres per second (m^3/s)	cubic feet per second (ft^3/s)	35.315	0.028317
	litres per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	litres per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic dekametres per day (dam^3/day)	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	metres per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	litres per minute per metre drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per litre (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimetre (uS/cm)	micromhos per centimetre	1.0	1.0
Temperature	degrees Celsius (°C)	degrees Fahrenheit (°F)	(1.8 × °C)+32	(°F−32)/1.8

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